Grimsha

THE

PUMP CATECHISM:

A PRACTICAL HELP TO

RUNNERS, OWNERS, AND MAKERS

OF

PUMPS OF ANY KIND.

COVERING THE THEORY AND PRACTICE OF DESIGNING, CONSTRUCTING, ERECTING, CONNECTING, AND ADJUSTING.

BY

ROBERT GRIMSHAW, M.E.,
Past Prest. James Watt Association, No. 7, of N.Y., N.A.S.E.,
Member Fulton Council, No. 1, of N. Y., A.O.S.E.
Author of "Steam Engine Catechism," "Boiler Catechism,"
"Square Root Made Easy," and many other
Practical Works.

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TO

EVERY ONE WHO WISHES TO KNOW
MORE TO-MORROW THAN HE
DID YESTERDAY.

CONTENTS.

PREFACE.

This book is for practical pump users. It is not for professional men, save as they may want to know how pumps are made and worked.

There is nothing heretofore published which describes the construction and operation of all the principal types and makes of pumps in use; nor how to take down, set up, adjust and run any single one of them.

Much of the special information herein contained had to be got by begging, coaxing, arguing and almost threatening; and can be had in no other form and in no other place.

All prominent pump makers in the United States were not only afforded opportunity to furnish data concerning the construction, operation, setting up and adjustment of their pumps, but were specially requested so to do. Some responded most willingly and freely; others

but tardily and incompletely. I offer no apology for according more space to the details of those pumps concerning which full data was furnished, than to those of the others.

If there is any practical question concerning any pump which is not answered in the following pages, I will take pleasure in answering it by mail, if possible, where stamp is inclosed; and will probably add such questions and answers to future editions, should they be called for.

5 Dey St., N. Y., December, 1886.

PUMP CATECHISM.

DEFINITIONS.

Q. What is a pump?

A. It is hard to get a definition that will cover the whole ground. A pump may be said to be a mechanical contrivance for raising or transferring fluids; and as a general thing consists of a moving piece working in a cylinder or other cavity; the device having valves for admitting or retaining the fluids.

Q. What two classes of operations are included in the term "raising" fluids?

A. They may be raised by drafting or suction, from their level to that of the pump; they may be raised from the level of the pump to a higher level.

Q. Do pumps always "raise" by either method, from one level to a higher one, the liquid which they transfer?

A. No; in many cases the liquid flows by gravity to the pump; and in some it is

delivered at a lower level than that at which it is received.

Q. Where a pump is not used for raising a liquid to a higher level, for what is it generally used?

A. To increase or decrease its pressure.

Q. What classes of fluids are handled by pumps?

A. Two; liquids and gases.

Q. Name some gases which are handled by pumps?

A. Air, ammonia, lighting gas, oxygen, etc.

Q. Name some liquids which are handled by pumps?

A. Water, brine, beer, tan liquor, molasses, acids and oils.

Q. Where it is not specified whether a pump is for gas or for liquid, which is generally understood?

A. Liquid.

Q. What gas is most frequently pumped?

A. Air.

Q. What liquid is generally understood if none other is specified for a pump?

A. Water.

Q. Can pumps handle hot and cold liquids?

A. Yes; though cold are easier handled than hot.

Q. What is the difference between a fluid and a liquid?

A. Every liquid is a fluid; every fluid is not a liquid. Air is a fluid; water is both a fluid and a liquid. Every liquid can be poured from one vessel to another.

SUCTION.

Q. What causes the water to rise in a pump by so-called suction?

A. The unbalanced pressure of the air, upon the surface of the liquid below the pump, forces the water up into the suction pipe, when the piston is withdrawn from the liquid.

Q. How much is the pressure of the atmosphere?

A. At the sea level about 14.7 lbs. per square inch, or 2096.8 lbs. per square foot.

Q. In what direction is this pressure exerted?

A. In every direction equally.

Q. What tends to prevent the water from being lifted?

A. The force of gravity, which is the result of the attraction of the earth.

Q. In what direction does the force of gravity act?

A. In radial lines towards the centre of the earth.

Q. With what force does this gravity act?

A. That depends upon the substance upon which it is acting.

Q. Why do you refer to the level of the sea in speaking of the pressure of the air and the weight of water?

A. Because the air pressure becomes less, as in rising above the sea level we recede from the centre of the earth, and the weight of a given quantity of water or of any other substance becomes less than it is at the sea level, as we approach to or recede from the centre of the earth.

Q. How is it that the weight of any substance becomes less if you go either above or below the sea level?

A. The farther you go from the earth, the less its attraction, and the less a given body will weigh upon a spring balance. The farther down into the earth you go, the nearer you get to the centre of the earth, at which, there being attraction upon all sides, any body would weigh

nothing. Going from the surface of the earth towards its centre, then, a body weighs less and less upon a spring balance.

Q. Why do you specify a spring balance?

A. Because in weighing by counterpoise, both the body to be weighed and the counterpoise by which it was weighed, would change their weights in the same proportion, as the position with regard to the centre of the earth was changed.

Q. By what may the pressure of the air be determined?

A. By what is called a barometer.

Q. How many kinds of barometer are there?

A. There are two principal kinds; the mercurial and the aneroid.

Q. What is a mercurial barometer?

A. In its simplest and most usual form, it consists of a glass tube, about 35 inches long, or less, closed at one end, and having its open end dipping beneath the surface of some mercury. The tube having been entirely filled with mercury, its open end having been temporarily closed and placed beneath the surface of the mercury reservoir, the pressure of the air

holds the mercury up in the tube, at a height of about 30 inches, more or less, according to the position with regard to the sea level, and to the condition of the atmosphere as regards dampness.

Q. What is in the space above the top of the column of mercury in the mercurial barometer?

A. A vacuum, unless there may be some slight vapor of mercury.

Q. Suppose water were substituted for mercury in making a barometer, how high would the column be if the vacuum was perfect?

A. About 33 or 34 feet.

Q. Could you make a column of mercury, thus held up by the unbalanced pressure of the atmosphere, fill a longer tube than 30 or 31 inches?

A. Yes; the length has nothing to do with it; it is a question of height above the level of the liquid in open air. By inclining the tube you might have a mercury column 10 feet or 100 feet long; but it would not be over 30 to 31 inches high, and the pressure at its base would only be about 14.7 pounds per square inch as a maximum.

Q. Is there any practical application of this principle to the placing and working of pumps?

A. Yes. You may make a pump "trail" water a very great distance, so long as the lift is not over 34 feet as a maximum.

Q. What limits the length of "trail" which can be given to the suction pipe of a pump?

A. The friction of the liquid in passing through a pipe, and perhaps the friction of the particles of liquid among themselves.

Q. Can water be drafted any greater height than 34 feet by any special device?

A. Yes; such an arrangement is shown in the accompanying sketch, contributed to the *American Machinist* by one of its correspondents. In the case which he quotes, the distance from the surface of the water to the suction valves of the pump was 37 feet, with but slight variations.

About 25 feet from the bottom end of suction pipe is a tee, with nipple and elbow. From this elbow a pipe, *b*, of the same diameter of the suction pipe, extends

to the same height, and is covered with a cap. The pump is connected to suction

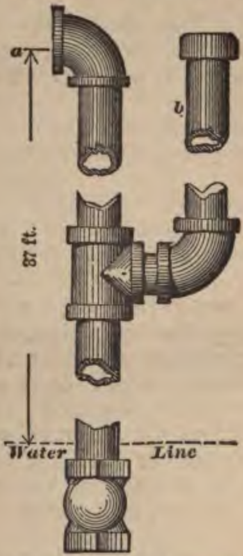

FIG. 1.—DRAFTING WATER OVER 34 FEET.

at *a*. There is a check valve at the bottom end of suction pipe. Fill both pipes

with water, then screw the cap air tight on the top of the stand pipe *b*. The action of the pump will suck the water out of the stand pipe, and form a vacuum in it that will sustain the water in the suction pipe, so that the pump will lift the water the 37 feet. (I cannot vouch for the working of the device).

Q. What are the causes which principally prevent pumps from lifting up to the normal maximum?

A. Friction; leakage of air into the suction, chokes in the suction pipe.

Q. Can a liquid be "drafted" without the expenditure of work?

A. No. In drafting a liquid to the full height to which it can be drafted, at least as much power must be expended as would lift the same weight of liquid that height by any mechanical means; only the amounts of friction being different.

Q. Then what advantage is there in having a pump draft its water to the full possible height, over having it force the water the full height?

A. Convenience in having the pump higher up.

Q. Can a pump throw water higher or

farther, with a given expenditure of power, where it flows in, than where it must draft its water?

A. Yes; on the same principle that it can throw farther or force harder where the water is forced to its suction side than where it merely flows in.

Q. What is the use of the suction chamber?

A. To enable the pump barrel to fill where the speed is high; to prevent pounding, when the pump reverses.

Q. Upon what does the lifting capacity of a pump depend?

A. When the pump is in good order its lifting capacity depends mainly upon the proportion of clearance in the cylinder and valve chamber to the displacement of the piston and plunger.

Q. Which will lift further, an ordinary piston pattern pump or a plunger pump? and why?

A. Other things being as nearly equal as they can be made between these two pumps, the piston pump will lift the farther of two, because the plunger pump has the most clearance.

Q. What is the advantage of the suc*tion chamber?*

A. To assist the pump in drafting, especially at high speed.

FORCING.

Q. What is the advantage of the air chamber?

A. To make the stream steady.

Q. What difficulty is sometimes met with in using an air chamber?

A. Where the pressure is very great sometimes the air is absorbed by the water, and thus the cushion is destroyed.

Q. How may this be remedied?

A. One of the best ways is to have a closed rubber bag filled with air, which will have all the elasticity of the air space, without being liable to lose its cushion power.

Q. Where has this been applied with especial success?

A. In fire engines.

Q. What will be the volume of the air in the air chamber of a force pump, when the pump is forcing against a head of 33.8 feet?

A. It will be reduced to half its ordinary volume, because it will be at the pressure of two atmospheres.

Q. "What is the reason that a steam
mp of the horizontal double-acting type
ould throw an intermitting stream under
ssure, like the stream from milking a
v, only not quite so bad as that?
"I have tried valves of different sizes,
h different amount of rise, springs or
ves of different tension, different kinds
packing in water piston, and different
ed water ports or passages, without any
parent difference."

A. Steam pumps of the horizontal
uble-acting type are not alone in throw-
an intermitting stream. The same
ng shows up in vertical single-acting
mps; and all horizontal double-acting
mps do not so behave. The steam fire
gine shows that no type of pump is ex-
pt from "squirting."

Q. How may this squirting be less-
ed?

A. By increasing the suction valve
a; by giving more suction chamber
d more air chamber; also by putting
the air chamber a rubber balloon full
air.

KINDS OF PUMPS.

Q. Name some of the principal classes

of pumps, as regards their general principles of action?

A. Rope, chain, cane, diaphragm, jet, centrifugal, rotary, oscillating and cylinder.

Q. What is a rope pump?

A. One in which, by the rapid and continuous motion of an endless rope which hangs in the reservoir, water is carried up to or near to the wheel over which the rope runs at the top; the water being there led off by a suitable conduit.

Q. What is a chain pump?

A. A development of the rope pump; an endless chain carrying a number of disks which fit, though not very tightly, in a long tube, extending from below the water up to where the latter is needed. The rapid continuous motion of the chain over a wheel at the top keeps the tube or barrel fairly full of water.

Q. What is a cane pump?

A. There is a cylinder, the lower end of which dips below the surface of the reservoirs, and the upper end of which is at the discharge point; a foot valve or check valve below the water level admits water when the cane or cylinder is lower-

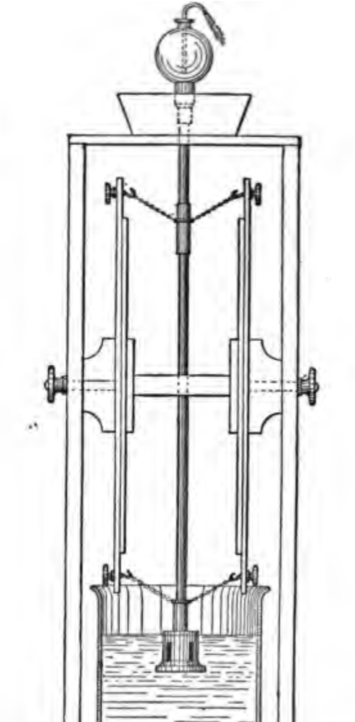

FIG. 2.—CANE PUMP.

ed, and prevents its exit when the barrel is raised.

Q. What is a diaphragm pump?

A. One in which the suction or discharge, or both, are caused by the motion of a flexible diaphragm attached to a rod, cord or chain, so that the volume of the chamber of which the diaphragm forms part of the wall is caused to change.

Q. What is a jet pump?

A. One in which the fluid to be pumped is moved by the action of a jet of the same or another fluid.

Q. Give a familiar example of this?

A. An ordinary boiler feeding injector, in which water is forced by the action of a flow of steam.

Q. May a jet pump either lift, or force, or both?

A. Yes.

Q. May either a liquid or a gas be made to pump either a liquid or a gas in a jet pump?

A. Yes.

Q. Is the duty or efficiency of jet pumps high?

A. No; generally very low.

Q. What is a rotary pump?

A. One in which, by the continuous rotation of one or more winged pistons in a cylinder, a vacuum, or partial vacuum, is formed and the water rushes up to supply

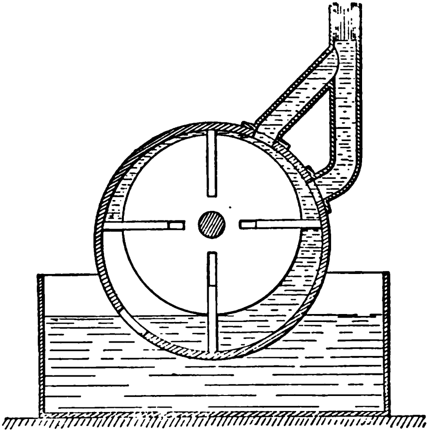

FIG. 3.—ROTARY PUMP SINGLE REVOLVER.

its place; being swept up and discharged by the rotating wing or wings.

Q. Describe a rotary pump having one piston?

A. There is an inlet opening, past which the wing which fits air tight in the chamber sweeps. As the wing recedes from the inlet, it forms a partial vacuum and the water rushes in, filling the chamber behind the wing. On the completion of the rotation, this charge of water is swept before the wing, and the space behind the latter is filled with a new charge.

Q. Why do you say "rotation?" Why not use the ordinary word "revolution?"

A. Because, strictly speaking, a body rotates around an axis within itself, but revolves about one outside of itself. Thus the earth rotates on its own axis and revolves around the sun.

Q. Describe a rotary pump with more than one so-called piston.

A. There are practically two gear wheels with one or more teeth each; these wheels meeting air tight with each other, and these teeth fitting air tight against the walls of the chamber or so-called cylinder. As the teeth, which constitute the wings, sweep past the inlet orifice, they make behind them a vacuum which the water tends to fill, and on the next rotation they sweep this water before them, out of the dis-

charge orifice. The flat ends of the revolvers fit air-tight against the end walls of the chamber.

Q. What is an oscillating pump?

A. As generally applied, the term refers to that class of pump in which the piston, or what correspondends to it

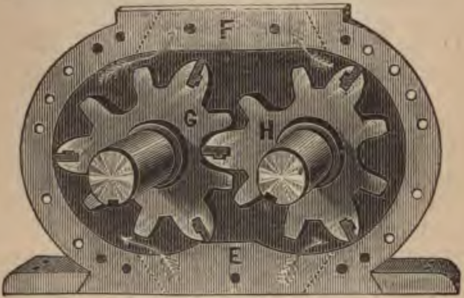

FIG. 4.—SILSBY ROTARY PUMP.

works in the arc of a circle, partially around some real or imaginary centre of motion.

Q. What other meaning might the term have?

A. It might mean a pump which had pistons reciprocating in cylinders, which

latter swung about a central point of motion.

Q. What is a direct steam pressure pump?

A. One in which the liquid is pressed out by the action of steam upon its surface, without the intervention of a piston. Among these we may mention the *montjus* used in sugar refineries, etc., and the "pulsometer" (which see).

Q. What is a cylinder or reciprocating pump?

A. One in which there is a cylinder in which there fits, air tight, a reciprocating piston or plunger. Motion of this piston or plunger in one direction causes a partial vacuum, to fill which the water is pressed by the atmospheric pressure, or by its head or other pressure. A suction valve prevents the return of this inrushing water on the return stroke of the piston or the plunger; and a discharge valve permits the outward passage of the fluid from the pump, but not its return thereto, or to the reservoir through the suction pipe. (When a valve is spoken of, it is understood that there may be several valves dividing and performing the functions of one.)

Q. What is a sinking pump?

A. One which can be raised and lowered conveniently, for pumping out drowned mines, etc.

Q. Into what main general classes may reciprocating cylinder pumps be divided?

A. Into single acting and double acting.

Q. What is a single acting reciprocating pump?

A. One in which each reciprocation or single stroke in one direction causes one influx of fluid, and each reciprocation or single stroke in the opposite direction causes one discharge of fluid. In other words the pump, as regards its action, is single ended.

Q. What is a double acting reciprocating pump?

A. One in which each end acts alternately for suction and discharge. Reciprocation of the piston in one direction causes an influx of fluid into one end of the pump from the source, and a discharge of fluid at the opposite end; on the return stroke the former suction end becomes the discharge end. In other words, the pump is double ended in its action; or is "double acting."

Q. What is the special advantage of having double acting pump cylinders?

A. The column of water is kept in motion more constantly, and hence there is less jar; smaller column pipes may be used.

Q. Properly speaking, what is a piston pump?

A. One in which there is a cylindrical reciprocating piece fitting air tight in a cylinder, and actuated by a piston rod having considerably less area of cross-section than the piston head.

Q. Into what classes may piston pumps be divided?

A. In some very familiar types of piston pumps, there is a valve in the piston head permitting the passage of fluid through it. In others the piston is "solid;" that is, no fluid passes through it.

Q. What is a plunger pump?

A. One in which the reciprocating portion which enters the pump barrel and fits air tight therein is of the same area throughout. No fluid passes through it. It acts by its displacement only.

Q. What is the special advantage of plunger pumps?

A. They have less friction than piston pumps, and the packing is more readily got at to adjust.

Q. What is one of the disadvantages of a plunger pump?

FIG. 5.—VALVED PISTON, SINGLE ACTING PUMP.

A. It takes up more room than a piston pump.

Q. What may be said of double acting piston pumps?

A. They act as though they were double acting plunger pumps; they are so in effect.

Q. As what may the bucket plunger pump be classed?

A. As an ordinary lift pump, backed with a plunger of half its area. (See under "Special Makes of Pumps.")

FIG. 6.—LETESTU'S VALVED PISTON PUMP.

FIG. 7.—SOLID PISTON, WITH LEATHER PACKING.

Q. What are the different classes of pumps, as regards the method of driving them?

A. They may be driven by hand or by "power."

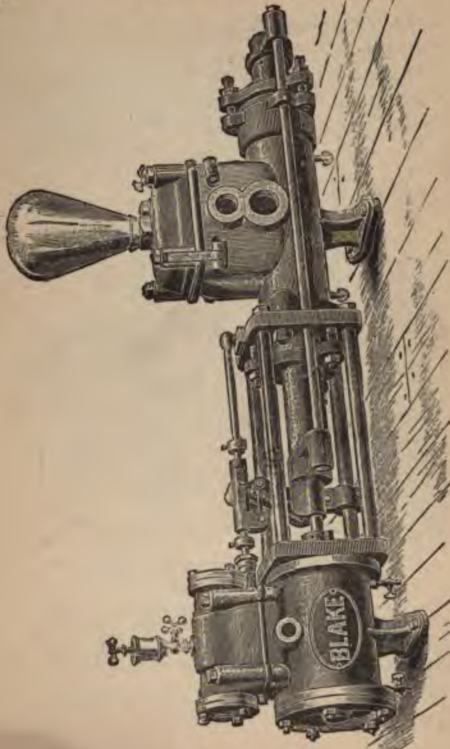

FIG. 8.—BLAKE PLUNGER PUMP.

Q. What are the classes of power pumps?
A. Those driven by belt and by gearing with a connecting rod from a crank or eccentric, and by steam against a piston.

Q. What are the advantages of belted power pumps?

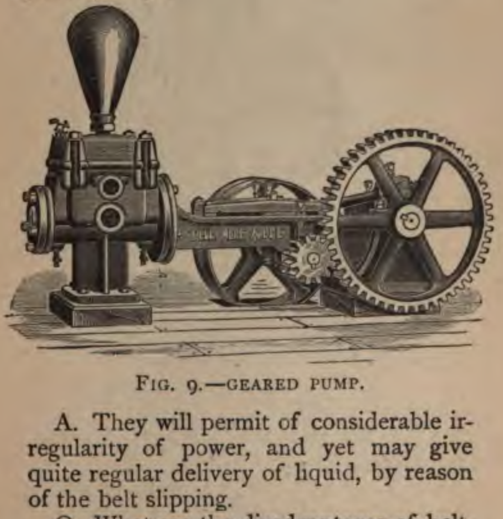

FIG. 9.—GEARED PUMP.

A. They will permit of considerable irregularity of power, and yet may give quite regular delivery of liquid, by reason of the belt slipping.

Q. What are the disadvantages of belted pumps?

A. As fire pumps they are apt to be crippled when most needed; they cannot be given as many changes of speed as direct acting or other self-contained pumps.

FIG. 10.—FLY WHEEL PUMP.

Q. What is the advantage of geared pumps?

A. They are positive in their action, hence do not slip under great pressure.

Q. How may those pumps which are

driven by steam against a steam piston be divided?

A. Into those which have a fly wheel, and those which have no fly wheel.

Q. Into what classes may those pumps which are driven by steam, without a fly wheel, be divided?

A. Into direct acting and duplex.

Q. What is the advantage of a fly wheel steam pump?

A. Steadiness of action; the capability of using the steam expansively.

Q. What are the disadvantages of fly wheel pumps?

A. Great weight; inability to run them very slowly without gearing down from the fly wheel shaft, as the wheel must run comparatively rapidly.

Q. What two ways are there of driving a fly wheel pump with a crank?

A. By a "Scotch yoke," and by a connecting rod.

Q. What is the advantage of the Scotch yoke?

A. The first half of the out stroke of the yoke corresponds to the first quarter of the crank revolution; and so on all around the revolution. This is not the

case with the connecting rod, in which each quarter of the revolution of the crank corresponds to more or less than a half stroke of the piston or plunger.

Q. What is a direct acting steam pump?

A. One in which there is no rotary motion, the piston being reversed by an

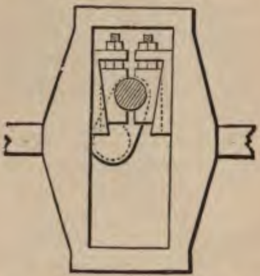

FIG. 11.—CLAYTON'S SCOTCH YOKE.

impulse derived from itself at or near the end of each stroke. There is but one steam cylinder for one water cylinder; the valve motion of the steam cylinder being controlled by the action of the steam in that cylinder.

Q. What is the peculiarity of the duplex type?

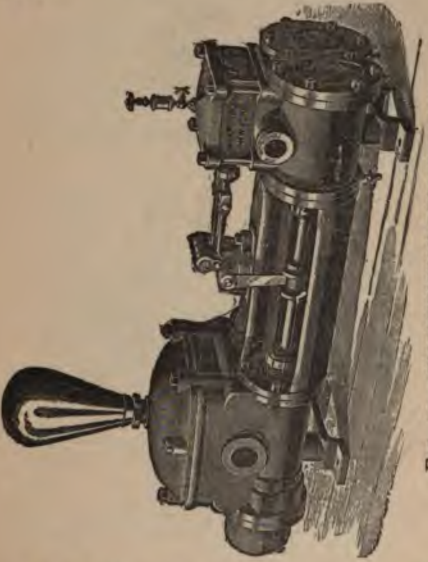

FIG. 12.—WORTHINGTON DUPLEX PUMP.

A. There are two steam cylinders and two water cylinders; the piston of one of these cylinders works the valve of the

other cylinder, and *vic*
half can work alone.
tirely arbitrary.

Q. How would yo
machine in which th
cylinders, each operat
in line with it; each
pumping machine
other side?

FIG. 13.—BLAK

A. A "do
Q. Can a
use steam ex
A. Not to
would be da
centres in mo
expansion.

other cylinder, and *vice versâ.* Neither half can work alone. This name is entirely arbitrary.

Q. How would you call a pumping machine in which there were two steam cylinders, each operating a water cylinder in line with it; each half being a perfect pumping machine independent of the other side?

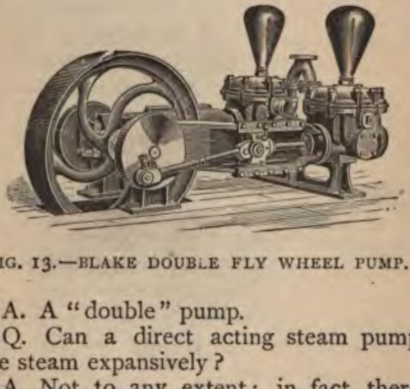

FIG. 13.—BLAKE DOUBLE FLY WHEEL PUMP.

A. A "double" pump.

Q. Can a direct acting steam pump use steam expansively?

A. Not to any extent; in fact there would be danger of sticking upon the centres in most cases, if there was lap and expansion.

Q. What is the reason that a single cylinder engine cannot well reverse itself without a fly wheel, by means of the ordinary single D valve?

A. Because when the valve was at mid travel, both parts of the valve seat would be closed by the valve faces, and neither exhaust nor admission take place.

Q. What means are employed in a direct acting steam pump to move the valve?

A. A small supplementary piston is used; this supplementary piston being actuated by the main piston in any one of several different ways.

Q. What are the principal ways of working the supplementary piston from the main piston?

A. (1) The main piston strikes the tappet of a small valve, which opens an exhaust passage in one end of the cylinder, containing a supplementary piston, and having live steam pressing upon both ends of the supplementary piston; (2) by the main piston striking a rod passing through the cylinder head, and moving a lever which controls the motion of the part of the main valve, to which is at-

tached the valves which move the supplementary piston; (3) the main piston rod carries a tappet arm, which twists the stem of the supplementary piston, thus uncovering ports which cause its motion; (4) a projection upon the main piston rod engages the stem and operates the valve which moves the supplementary piston; but if that valve should not, by means of its steam passages, cause quick enough or sure enough motion of the supplementary piston, a lug upon this stem moves the supplementary piston.

Q. In the first of these four classes, what is the principal element in the valve motion?

A. A difference in area between the eduction port of the supplemental piston and its induction ports.

.Q What is the principal feature in the second class?

A. A regular slide valve letting steam upon alternate ends of the supplemental piston.

Q. In the third class, what is the main feature?

A. A twisting motion in the supplemental piston.

Q. In the fourth class, what is the principal feature?

A. Movement of the supplemental piston by steam controlled by a slide valve, and by the mechanical action of the slide valve itself if its steam distribution is defective.

Q. What are the objections to most pumps of the direct acting type?

A. The unbalanced condition of the auxiliary pistons in the exhaust side, causing a loss of steam when the parts are worn; the choking up of the small ports for the auxiliary pistons, by the gumming and caking of the oil therein.

Q. Can the ordinary direct acting steam pump use steam expansively?

A. No.

Q. How may this be done?

A. By compounding.

Q. What is to be taken into consideration in the use of compound steam pumps?

A. That they are designed for a certain range of pressure—say from 40 to 60 pounds boiler pressure, and will do their best work between these pressures.

Q. Have all direct acting steam pumps *intermittent valve* motion?

A. No; there are some which have continuous valve motion.

Q. In most direct acting steam pumps, are the auxiliary piston heads made together or in separate pieces?

A. Together.

Q. Are they in contact with the steam in the chest?

A. Yes.

Q. What is the usual outline of the ports of the auxiliary steam pistons in most direct acting pumps?

A. Thus:

Q. What is the objection to this?

A. Oil and condensed steam collect there, and there is a tendency for them to get gummed up.

KINDS OF VALVES.

Q. What are the principal kinds of water valves used?

A. They are generally three: hinge (also called clappets), poppet and ball. There are some which are combinations of the first two, as, for instance, in the Carricaburu pump, where the water

valves both swing and lift. (See under this head.)

Q. What are the advantages of the hinge valve?

A. It will let comparatively large bodies pass through it.

Q. What is the advantage of the poppet valve?

A. Compactness; capability of being adjusted as to lift and as to quickness of

FIG. 14.—BALL VALVE.

closing, and of being constructed of almost any desired material.

Q. What is the advantage of the ball valve?

A. It can be worked very hard with little injury to itself or to its seat; does not clog up as does the poppet.

Q. What other valves may be mentioned?

A. Conical, in which the action is like that of two hands placed palms together

FIG. 15.—FLEXIBLE VALVES.

and flexible, which are practically a prolongation of conical valves, permitting solid substances of irregular shape and considerable length to pass through them, the valve closing before and behind the body referred to.

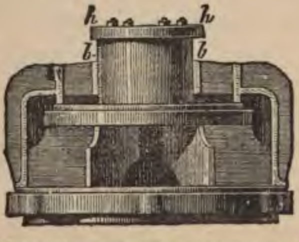

FIG. 16.—DOUBLE BEAT VALVE.

Q. Where are such valves used?
A. In cesspool pumps.

FIG. 17.—DOUBLE BEAT VALVE (SECTION).

DESIGN AND CONSTRUCTION.

Q. What is necessary in order that there shall be no danger of the main piston head knocking the cylinder head?

A. That the main valve shall lead the piston.

Q. What can be said of the arrangement of the water valves?

A. They should have as short passages and as few turns in them as possible, to lessen the friction.

Q. For very heavy water pressure, what precaution should be taken with the valves?

A. They should be allowed to seat thoroughly, by making the piston stop and start slowly at the end of each stroke.

Q. What amount of lift must a poppet valve have, in order to give an area of discharge equal to the area of the opening?

A. One-quarter of the diameter. Thus a valve 3 inches in diameter has an area of $3 \times 3 \times .7854 = 7.0686$ square inches; i's circumference is $3 \times 3.1416 = 9.4248$ inches. Now as $9.4248 \times \frac{3}{4} = 7.0686$, we have a full circular area of the valve diameter given by a lift of only $\frac{1}{4}$ the diameter. This is true of any other diameter of valve.

Q. What limit should be put to the motion of a hinge valve, and why?

A. It should not go beyond the 45° line, so that it will be liable to seat more freely.

Q. Where is the best place for the suction valve of a piston pump?

A. As near the piston as possible, to lessen the clearance.

Q. What should be the capacity of the air chamber for ordinary pumps?

A. About 12 to 15 times the capacity of the barrel.

Q. For fire engines, what should be the capacity of the air chamber to give the best results?

A. About 20 times that of the cylinder. Thus a cylinder 4×6 having a capacity of $4 \times 4 \times .7854 \times 6 = 75.4$ cubic inches, would call for a sphere having a diameter of $\sqrt[3]{75.4 \times 20 \div .5236} = \sqrt[3]{3071} = 14.53$ inches.

Q. For deep well pumping, where should the pump cylinder be placed?

A. As near the water as possible.

Q. For deep well pumping, where should the steam cylinder be placed?

A. As near the surface of the ground as possible.

Q. Why should the steam cylinder of a pump be near the surface of the ground?

A. So that it may be attended to readily.

Q. For vertical work, how may the motion of the pump piston be made uniform upon the up and the down strokes?

A. By having a separate valve for each end.

Q. For deep vertical work, should there be a counterbalance?

A. It is best for very large sizes.

Q. What is a good arrangement for hydraulic pumps?

A. To have two, one of which shall work fast, up to a certain pressure, at which it will stop and the other one do the rest of the work more slowly.

Q. In case the liquid to be pumped is very strongly acid, what may be done?

A. There may be used a removable cylinder lined with porcelain.

Q. What is the advantage of having removable cylinders?

A. The pump may be used for different service by using cylinders with smaller bores for greater work. Railroads having a great number of pumps along their line requiring different service, can keep one line of extras and repairs, except cylinders, for all the pumps along the line.

Q. What special precaution should be taken where the water is very greasy?

A. To have the pump cylinders lined with a removable bush of gun metal or other bronze.

Q. Is it necessary to change the lining of a pump cylinder when it becomes worn?

A. Not always. In some cases it may be turned as it gets worn slightly out of round.

Q. What is one special advantage in having a removable bush or lining in the water end of a pump?

A. If the pressure is too great for the size of bore first given, a thicker lining may be used, so as to take a piston of smaller diameter and enable greater pressure to be pumped against.

Q. What is the use of the hand power attachment upon boiler feeding pumps?

A. They may be used when steam is down, to feed the boilers, wash decks, etc.

Q. What is the advantage of a short stroke pump?

A. Compactness.

Q. What is the disadvantage of a short stroke pump?

A. Increased number of reversals.

Q. What is the advantage of having an independent condenser to an air pump?

A. A vacuum may be formed for the steam cylinder before the machine is started up.

Q. Is there any substitute for the fly wheel upon the steam end of a pumping engine?

A. Yes. The Worthingtons employ, in some of their engines, two small oscil-

lating cylinders attached to an extension of the plunger rod of the engine, preferably beyond the water end. These cylinders and their connecting pipes are filled with water or other liquid. Compressed

FIG. 18.—BLAKE INDEPENDENT AIR PUMP AND JET CONDENSER.

air from a storage tank is admitted at a suitable pressure to maintain a constant load upon the pistons in the cylinders, through the medium of the interposed water. These pistons act in such a way

with respect to the motion of the engine, as to resist its advance at the commencement of the stroke and assist it at the end; the air, meanwhile, exerting its unvarying pressure at each point of the stroke. By alternately taking up and exerting power through the difference in the angle at which their force is applied with respect to the line of motion of the plunger rod, these two cylinders in effect perform the functions of a fly wheel; but they utilize the constant pressure of the compressed air instead of the energy of momentum.

Q. What is claimed for this device as against fly wheels for pumping engines?

A. The regularity of its action is independent of the speed at which the engine is run. They are as good regulators at 10 strokes per minute as at 100.

Q. About what proportion of pump and steam cylinders should be taken for condenser circulating pumps?

A. The steam cylinder should have about $\frac{1}{3}$ the area of the water cylinder, so that for 10 pounds water pressure or less, about 35 pounds steam pressure would move the pump.

Q. What should be said about the location of a pump?

A. It should be as near the source of supply as is convenient.

Q. A "Nye vacuum" pump is used for supplying a quarry. The pump now stands in the boiler room, and draws the water through 250 or 300 feet of suction pipe. Soon the lift will be too great as we go deeper. Will it be perfectly practical to place the pump at the bottom of the hole and supply it with steam from the present boiler? The steam pipe, of course, to be well covered.

A. The pump has a good long "trail" as it is. Perhaps with less trail it would stand more lift; and the trouble of placing the pump out of the reach of regulation would be avoided. It might not be a very expensive matter to put the pump at the top of the hole and *force* the 250 or 300 feet horizontally; you would save the cost of steam pipe down to the bottom of the hole, and of erecting the pump down there. A foot-valve to suction pipe might help things. But I see no reason why the pump would not work at the bottom of the hole—or part way down if more con-

venient. Care should be taken, as you say, to lag the steam pipe so as to prevent condensation and loss of pressure. A trench full of sawdust is a good non-conductor, where it can be kept *dry*.

Q. What may be said about convenience in repairs?

A. The pump should have room left upon all sides; and upon both ends equal to its length, for the removal of the piston rods in case of repairs.

Q. What is the best foundation for pumps?

A. A good plank floor is good enough for most small pumps; skids for larger ones.

Q. If the floor is not strong enough, how may a good foundation be made?

A. By digging 2 or 3 feet into the ground and building up the proper height with stone or brick laid in strong cement.

Q. What may be said about suction pipes?

A. They must be as large as possible; the longer they are the greater in diameter they should be; they should be as straight as possible, and as free from bends and valves; they must be air tight; they must

not be allowed to get obstructed by foreign substances.

Q. What may be said about the area of strainer holes?

A. They should have an aggregate area about 5 times that of the suction pipe.

Q. Where are foot valves necessary?

A. Upon long suctions or high lifts.

Q. Should two pumps take their suction from one pipe?

A. It should be avoided, unless the pipe is very large; and in any case both suctions should be arranged so that one of the pumps should not have to draft at right angles to the flow of water going to the other pump.

Q. What arrangement should be made where it is necessary to have two pumps draft from one suction?

A. There should be a Y connection.

Q. What is a good way to reduce the friction in suction pipes where there are many bends?

A. To use bends of wrought-iron pipe of as long a radius as possible, instead of cast-iron elbows.

Q. What may be said about the lower end of the suction pipe?

A. It should generally have a strainer; and if the lift is over 12 to 15 feet, should have a foot valve.

Q. What is a good thing to do with the discharge pipe near the pump?

A. To put a check valve in it near the pump, to keep back the water in the pipe when the water end is to be opened for inspection or repairs.

Q. What provision should be made for priming the pump?

A. There should be a pipe with a stop valve in it connected from the discharge pipe beyond this check valve, or from some other source of supply, to the suction pipe, for the purpose of priming the pump.

Q. When the pump is in position for piping, what care should be taken?

A. That the pipes are of proper lengths, so as not to bring any undue strain upon them in connecting them to the pump, as in that case they will be liable to give trouble by breaking or working the joints loose and leaking.

Q. Does any pipe have an effective diameter as great as its nominal diameter?

A. No, because the sides retard the

flow of the liquid; there is a neutral film of liquid which practically does not move.

Q. Upon what does the thickness of this film of liquid depend?

A. Upon the viscosity (commonly miscalled the "thickness") of the liquid; upon the roughness, material and diameter of the pipe; the pressure, etc.

Q. When long lines of pipe are used, should the diameter of the pipe be the same all the way along, or should there by sections be decreasing diameter as the distance from the pump increases?

A. Most emphatically the pipe diameter should remain constant clear out to the end.

Q. What amount of power is consumed by friction of water in pipes?

A. The following table, on the authority of G. A. Ellis, gives this:

FRICTION OF WATER IN PIPES.

Friction-loss in pounds pressure per square inch, for each 100 feet of length in different size clean iron pipes discharging given quantities of water per minute.

Gallons per Minute.	Sizes of Pipes Inside Diameter.								
	¾ In.	1 In.	1¼ In.	1½ In.	2 In.	2½ In.	3 In.	4 In.	6 In.
5......	3.3	.84	.31	.12	....	...			
10......	13.0	3.16	1.05	.47	[illegible]				
15......	28.7	6.98	2.38	.97	...				
20......	50.4	12.3	4.07	1.66	[illegible]				
25......	78.0	19.0	6.40	2.62	...	[illegible]	[illegible]		
30......	....	27.5	9.15	3.75	[illegible]				
35......	....	37.0	12.4	5.05					
40......	....	48.0	16.1	6.52	[illegible]				
45......	....	....	20.2	8.15					
50......	....	....	24.9	10.0	[illegible]	[illegible]	[illegible]	[illegible]	
75......	....	....	50.1	22.4	[illegible]	[illegible]	[illegible]		
100......	....	....	....	39.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
125......	....	....	....	....	[illegible]	[illegible]	[illegible]		
150......	....	....	....	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
175......	....	....	....	....	[illegible]	[illegible]	[illegible]		
200......	....	....	....	....	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Gallons per Minute.	Sizes of Pipes—Inside Diameter.									
	2½ In.	3 In.	4 In.	6 In.	8 In.	10 In.	12 In.	14 In.	16 In.	18 In.
250.....	19.66	7.76	1.89	.26	.07	.03	.01	....	....	....
300.....	28.06	11.2	2.66	.37	.09	.04	....	....	....	....
350.....	....	15.2	3 65	.50	.12	.05	.02	....	....	....
400	....	19.5	4.73	.65	.16	.06	....	....	....	....
450.....	....	25.0	6.01	.81	.20	.07	.03	....	....	...
500.....	....	30.8	7.43	.96	.25	.09	.04	.017	.009	.005
750.....	....	....	....	2.21	.53	.18	.08	....	....	....
1000.....	....	....	....	3.88	.94	.32	.13	.062	.036	.020
1250.....	....	....	....	....	1.46	.49	.20	....	....	....
1500	....	....	....	....	2.09	.70	.29	.135	.071	.040
1750.....	....	....	....	....	....	.95	.38	....	....	....
2000.....	....	....	....	....	....	1.23	.49	.234	.123	.071
2250.....	....	....	....	....	....	....	.63	....	....	....
2500.....	....	....	....	....	....	....	.77	.362	.188	.107
3000.....	....	....	....	....	....	....	1.11	.515	.267	.150
3500.....	....	....	....	....	....	....	....	.697	.365	.204
4000.....	....	....	....	....	....	....	....	.910	.472	.263
4500	....	....	....	....	....	....	....	....	.593	.333
5000.....	....	....	....	....	....	....	....	....	.730	.408

Q. What is the best contour for pipe to be laid to, where the pipe is of uniform diameter?

A. To a uniform slope.

Q. What is the "hydraulic mean gradient"?

A. It is an imaginary straight line which is drawn through to the levels in a number of small vertical tubes tipped into the top of a sloping pipe, from the lower end of which the water was free to flow.

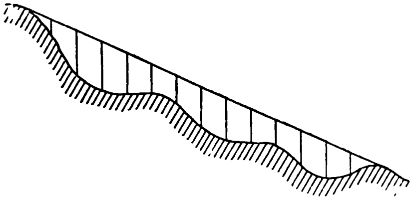

FIG. 19.—HYDRAULIC MEAN GRADIENT.

Q. Suppose the laid grade of the pipe was not regular, but that there was a hump which rose above the main; what should be done about the diameter of the pipe in this humped portion?

A. Referring to the figure: *A E* is the

level, *A F* the hydraulic mean gradient; now that part of the pipe between *C* and *D* should have a diameter larger than

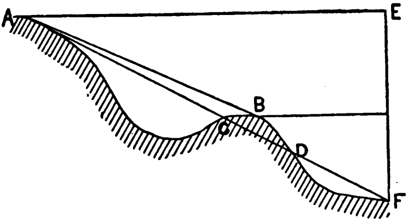

FIG. 20.—CONTOUR OF PIPE.

from *A* to *C*; from *D* to *F* it may be of smaller diameter.

Q. Supposing the diameter and length of two mains the same, what may be said of their discharges?

A. With constant diameter and length, the discharges are as the square root of the head; thus for heads of 1, 2 and 3, the discharges will be as 1, 1.414 and 1.732.

Q. How is the head, as calculated from the discharge?

A. It is directly as the square of the

discharge. Thus for discharges of 1, 2 and 3, there would be required heads of 1, 4 and 9; the diameter and length of pipe being the same.

Q. With the head and length of pipe constant, what is the law concerning the discharge?

A. With constant head and length, the discharge will be as the 2.5 power of the diameter of the pipe. Thus the diameters $1^{2.5}$, 2 and 3 will give discharges of $1^{2.5}$, 2, and $3^{2.5}$ = 1, 5.6 and 15.6.

Q. What is the relation between the diameter and the discharge, with constant head and length of pipe?

A. With constant head and length of pipe, the diameters will vary directly with the 2.5 roots of the discharges. Thus with discharges 1, 2 and 3 respectively, the diameters required will be $\sqrt[2.5]{1}$, $\sqrt[2.5]{2}$. $\sqrt[2.5]{3}$ = 1, 1.32, 1.55.

Q. With constant discharge and length of pipe, what will be the heads?

A. With constant discharge and length of pipe, the heads will be as the 5th power of the diameter. Thus for diameters 1, 2 and 4 there will be required heads of 4^5, 2^5 and 1^5 = 1024, 32 and 1.

Q. With constant head and diameter, to what will the discharges be proportionate?

A. With constant heads and pipe diameter, the discharges will be proportionate to the square root of the length of pipe; thus for lengths of 1, 2 and 4, the discharges will be as $\sqrt{4}$, $\sqrt{2}$, $\sqrt{1}$, or as 2, 1.414 and 1.0.

Q. With constant heads and constant pipe diameter, to what will the length of pipe be proportionate?

A. To the squares of the discharges. Thus, discharges 1, 2, 4, correspond to lengths of 4^2, 2^2, 1^2; or 16, 4 and 1.

Q. With discharge and pipe diameter constant, to what will the head be proportionate?

A. Simply as the length.

Q. What is Appold's modulus for pumps?

A. An arrangement by which a pendulum valve is opposed to the flow of water, and when the pressure increases, it swings over and partly closes the discharge opening.

Q. Is there any advantage in turning the exhaust of a steam pump into the *suction side of* the pump?

A. In many cases there is considerable advantage. It does away with the noise of the exhaust, and if properly done, reduces the back pressure upon the steam ends, thus practically making the steam cylinder "condensing" in its operation.

Q. Under what conditions would it be no advantage to turn the exhaust steam into the suction of the pump?

A. Where there would be any difficulty arise by reason of having the water heated by the exhaust; as for instance, where the water had to be drafted some distance by suction, or where cool water is desired for circulation purposes.

Q. In putting a pump together, what precaution should be taken as regards getting proper joints?

A. Wipe all parts before putting together.

Q. What precaution should be taken as regards all bolts and screws?

A. Oil them before putting in. A little graphite (black lead, plumbago) in the oil used for this purpose, is a desirable addition.

Q. What is the best height to place a centrifugal pump above the water?

A. Eight and one-half feet ($8\frac{1}{2}$.')

Q. At what height will a centrifugal pump give its best effect?

A. Seventeen feet (17'.)

Q. Above what height does a plunger pump do better then a centrifugal?

A. Thirty-four feet (34'.)

CARE AND USE.

Q. What can be said about taking care of a pump?

A. In places where an inferior grade of labor is employed, oil and dirt are sometimes found covering the steam chest and pump to the depth of an inch in thickness; stuffing boxes are allowed to go leaky and get loose; the valve motion is never looked after; lost motion is never taken up, and the pump will be let run along in a slipshod way for months until some accident occurs. This will sometimes exist in places where the engine is well taken care of.

Q. Should not as good care be taken of a steam pump as of an engine?

A. Yes. It is a steam engine, and the :t that it has generally but little adjust-

ability, should not render it liable to lack of care.

Q. What is a very common thing for pump runners to do when anything happens?

A. To condemn the pump at once, without finding out the cause of the trouble.

Q. What is one reason of this?

A. The man who understands an ordinary engine thoroughly, will often become quite perplexed when he examines the steam ends of a direct acting steam pump, because he does not comprehend the principal feature of its construction—that all direct acting steam pumps which have no fly wheels and cranks, must generally have an auxiliary piston in order to carry them over the "dead centre." A direct acting steam pump is really a double engine; a plain, flat slide valve admitting steam to a small piston, which in turn operates the main valve, which gives steam by the usual arrangement to the main piston.

Q. What would save firemen and engineers much trouble with steam pumps?

A. If they would take the trouble to

examine their pumps carefully, and find out the way their valves were arranged and actuated.

Q. Upon what does the successful performance of a pump depend, in great measure?

A. Upon its proper selection from among the many patterns, differing from each other in size, proportion and general arrangement.

Q. What may be said about the selection of pumps?

A. Pumps are often selected improperly for their work. As an illustration, a man who wishes to use a circulating pump for a surface condenser, where the water pressure upon the pump cylinder will never exceed 5 to 10 pounds, will buy a pump intended for boiler feed work, and having its steam cylinder about three times the area of its pump cylinder.

Q. What will be the result in such a case?

A. There will be little or no pressure in the steam cylinder when working on the condenser; and while there is pressure sufficient to move the main piston, there is not enough to operate the auxiliary piston with positiveness.

Q. In ordering a pump, or in asking estimates, what information should be given?

A. In ordering a pump, it is to the interest of the purchaser to fully inform the maker or seller on the following questions:

1st. For what purpose is the pump to be used? What is the average steam pressure?

2d. What is the liquid to be pumped; and is it hot or cold, clear or gritty, fresh, salt, alkaline or acidulous?

3d. What is the maximum quantity to be pumped per minute or hour?

4th. To what height is the liquid to be lifted by suction; and what is the length and diameter of the suction pipe, and the number of elbows or bends?

5th. To what height is the liquid to be pumped, and what is the length and size of discharge pipe?

Q. How can an engineer familiarize himself with the direction of the auxiliary steam and exhaust passages?

A. By means of a piece of wire.

Q. Do the pistons of a direct acting steam pump make the same length of stroke at all speeds?

...ed; not so tight as
...ion; nor so slack as

...be used in the steam
...pump?
...it corrodes the parts,
...eam pressure be high.
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...team end of a pump?
...passages of the aux-
...get foul with dirt, etc.,
...at into the working
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...xiliary piston will get
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...s and starts.
...best oil to use for this

...perm oil, valvoline, or
...with a reputation.
...best way to lubricate a
...m pump?
...ated steam, there is
...ny lubrication, the steam
...for the purpose. But
...ance use tallow or suet in
...structive to the hot
...chest and cylinder.

A. Very seldom.

Q. What is the special thing to look after in duplex pumps?

A. That all packings are adjusted uniformly upon both sides.

Q. What would be the result of having the packings different upon the two sides of a duplex pump?

A. The machinery would run unsteadily.

Q. If a pump works badly, what should be about the first thing to look at?

A. The connections.

Q. When a pump is first connected, what should be done?

A. It should be blown through to remove dirt; if it be of the class which will permit of removing the bonnets and blowing through, that should be done.

Q. What pump piston speed is recommended for continuous boiler feeding service?

A. About 50 feet per minute.

Q. What may be said about the care and use of steam pumps of all kinds?

A. It is important that the pump be properly and thoroughly lubricated; that *all stuffing* box, piston and plunger pack-

ings be nicely adjusted; not so tight as to cause undue friction; nor so slack as to leak badly.

Q. Should tallow be used in the steam cylinder of a steam pump?

A. No; because it corrrodes the parts, particularly if the steam pressure be high.

Q. What is the disadvantage of using common oil in the steam end of a pump?

A. The ports and passages of the auxiliary cylinder often get foul with dirt, etc., which will finally eat into the working parts, and after a while make them leak steam. Or the auxiliary piston will get gummed up, and the pump either refuse to run or run by fits and starts.

Q. What is the best oil to use for this purpose?

A. First-class sperm oil, valvoline, or some other lubricant with a reputation.

Q. What is the best way to lubricate a direct acting steam pump?

A. With saturated steam, there is scarcely need of any lubrication, the steam being wet enough for the purpose. But under no circumstance use tallow or suet in any pump—it is so destructive to the hot wearing surfaces of the chest and cylinder.

Q. In which end of a steam pumping machine is there most likely to be trouble?

A. In the water end.

Q. If a pump slams and hammers in its water end, is it necessarily defective in its water cylinder?

A. No; it may be that there is no suction chamber, or not enough; or sometimes it slams because the suction pipe is not large enough.

Q. What are very common defects in cheap grades of pumps?

A. Too little valve area in the pump end; too great lift for the valves.

Q. What are the principal causes of pumps refusing to lift water from the source of supply?

A. Among these may be mentioned leaky suction pipes, worn out pistons, plungers, packings or water valves; rotten gaskets on joints in piping or pump; and sometimes a failure to properly prime the pump as well as the suction pipe.

Q. What is one great cause of a pump refusing to lift water when first started?

A. It often happens that a pump refuses to lift water while the full pressure against which it is expected to work is

resting upon the force valves, for the reason that the air within the pump chamber is not dislodged, but only compressed, by the motion of the plunger. It is well, therefore, to arrange for running without pressure until the air is expelled, and water follows; this is done by placing a check valve in the delivery pipe, and providing a waste delivery to be closed after the pump has caught water.

Q. Sometimes when starting, the water may not come for a long time; what is the best thing to do in this case?

A. First open the little air cock, which is generally located in the top of the pump, between the discharge valves and the air chamber, to let off any accumulation of air which may there be confined under pressure. Very often, by relieving the pump of this air pressure, it will pick up its water by suction, and operate promptly.

Q. If a hand pump works badly, how is the suction sometimes improved?

A. By working it very fast to get it started.

Q. What is the reason for this?

A. There is less time given for the air to leak in.

Q. What precaution must be taken in priming the pump?

A. The air cock, which should be provided at the top of the pump, should be opened, to allow the escape of the air from the suction pipe and from the pump, and then the valve in the priming pipe should be opened. The pump should then be started slowly, as it aids in more completely filling the pump cylinders, which otherwise might not occur, and the pump might fail to lift water.

Q. Is there any advantage in having air in the suction?

A. Sometimes a small amount of air let into the suction will cause less jarring when the duty is very heavy.

Q. Is it safe to suddenly let a direct acting steam pump "suck wind?"

A. There are very few direct acting pumps in which there would not be danger of knocking out the heads in such a case.

Q. What may be said about pumping hot water?

A. Where the hot water is very hot, it should gravitate to the pump, instead of an attempt being made to draft it.

Q. In plunger pumps, what is about the only wearing part at the water end?

A. The packing of the plunger stuffing-boxes.

Q. How can a pump be prevented from freezing?

A. By having draining cocks and opening them when the pump is idle.

Q. What may be said about leather piston packing for water cylinders?

A. For cold water, or sandy, gritty water, the leather packing has many points to commend it; it makes a tight piston, and one that is the least destructive to pump cylinders.

Q. What is the best way to handle the square packing mostly employed, which is composed of alternate layers of cotton and rubber?

A. Cut the lengths a trifle short, then there will be room for the packing to swell, and not cause too much friction. I have known pistons where this precaution has not been taken to be fastened so securely in the cylinder by the swelling of the dry packing, that full steam pressure could not move them.

Q. What is the remedy in such a case?

A. Remove the follower, take out the different layers of packing and shorten their lengths.

Q. What is the reason that some soft waters corrode pipes so often?

A. Because they contain a large proportion of oxygen.

Q. Will a pump with a 4" water cylinder and a 4" steam cylinder force water into a boiler, the discharge pipe from water cylinder being 4" diameter; boiler pressure 80 lbs.?

A. A pump with a 4" water cylinder and 4" steam cylinder will not force water into the boiler which supplies it, no matter what the steam pressure nor what the size of discharge pipe. It will not move. The pressures would be equalized and there would be nothing to overcome friction of steam and water in pipes and cylinder.

The foregoing case supposes that the water is to be lifted to the pump; or at least that there shall be no head; also that there shall be no fall from pump to boiler.

If there were sufficient head or fall to overcome all the various frictions, and no

lift, the pump would apparently work; but really the water piston would be dragging the steam piston along.

Q. How may acids be pumped?

A. By what is known as blowing up; that is by employing a pump to put pressure upon the acid in a closed vessel, thereby forcing it through a pipe placed in the bottom of the vessel.

Q. In case any wearing part of a pump gets to cutting, what should be done?

A. If it is not practicable to stop the pump, nor to reduce its speed, the part which is getting damaged should be given very liberal oiling.

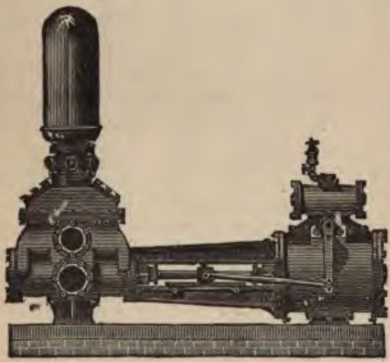
Q. What is the best oil for this purpose?

A. That depends on the nature of the cutting surfaces, and on the pressure therein; the mineral oils are generally more cooling than others, although they have less body to resist squeezing.

Q. What may be said of mercury (quicksilver) as a cooler?

A. It has a good reputation in this respect. Applied to brass bearings it forms an amalgam therewith; dissolving off the roughness and forming with the dissolved

material a pasty substance. It is somewhat too expensive for frequent use, or for application to very large bearings; besides which it is troublesome to handle and apply. There are cheaper things which are more effectual and less troublesome.



SPECIAL MAKES OF PUMPS.

Q. What is the Acme steam pump?

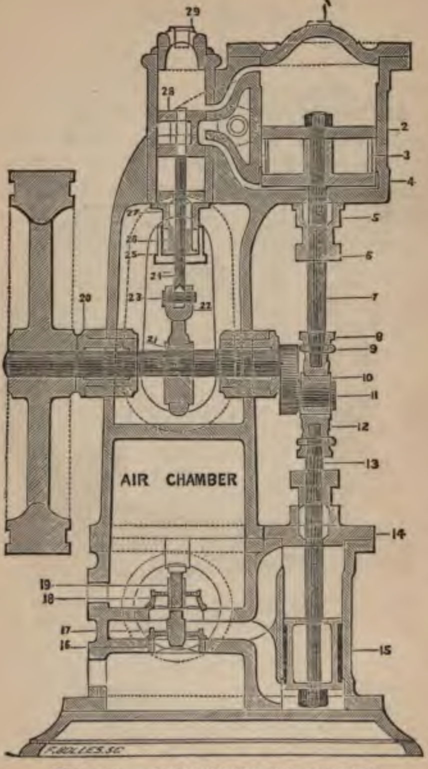


FIG. 21.—ACME PUMP IN SECTION.

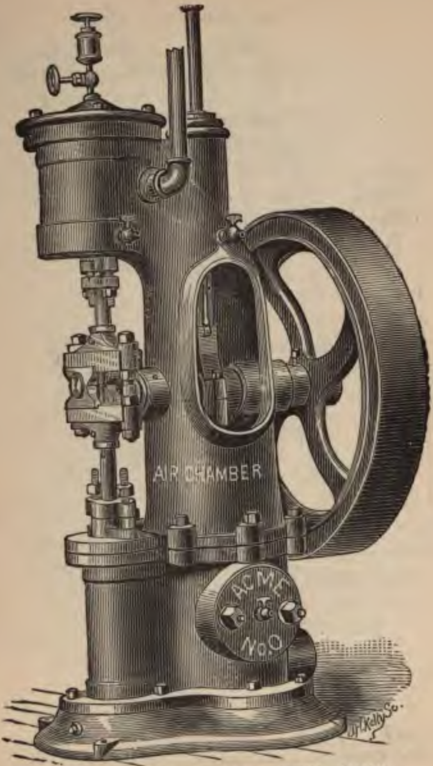


FIG. 22.—ACME FLY WHEEL PUMP.

ACME STEAM PUMP.

1. Cylinder Head.
2. Piston Follower.
3. " Rings.
4. " Head.
5. " Stuffing Box.
6. " Stuffing Box Gland.
7. " Rod.
8. Upper Yoke.
9. Yoke Pin.
10. Slide Box.
11. Crank Pin.
12. Lower Yoke.
13. Plunger Rod.
14. Water Cylinder Head.
15. Water Plunger.
16. Lower Valve Seat.
17. Lower Valve.
18. Upper Valve Seat.
19. Upper Valve.
20. Shaft Box.
21. Eccentric.
22. Eccentric Strap.
23. Valve Stem Pin.
24. Valve Stem.
25. " " S. Box Nut.
26. " " S. Box Gland.

27. Valve Stem Stuffing Box.
28. Steam Valve.
29. Valve Chest Nut.

A. It is shown in figure 21, which has proper reference numbers. It differs from the "bucket-plunger" pump, in having the regular four-valve, double-acting piston water-end, discharging the full contents of the water cylinder at each single stroke. It can be used as a motor by removing the plugs in the base, which allow the air to come in the drip.

Q. How would you examine and take apart an Acme pump?

A. To examine water valves, remove hand-hole covers—both sides.

To remove water valves, drive out the tapering wedges that hold upper seats in place and remove upper seats, when lower valve can be taken out through opening made by the removal of the upper or discharge valve seat.

To remove water piston, drive out tapering pins from upper and lower yokes, remove yokes from rods, unscrew bolts in water cylinder head, and lift out water piston and rod, taking along with them *the water* cylinder head.

To set or take up wear in slide box, and to remove steam piston, same as in Bucket Plunger pump (which see).

Q. What is the construction and operation of the steam end of the Blake pump?

A. The main valve, which controls the admission of steam to, and the escape of steam from, the main cylinder, is divided into two parts, one of which, *C*, slides upon a seat on the main cylinder, and at the same time affords a seat for the other part, *D*, which slides upon the upper face of *C*. As shown in the engravings, *D* is at the left-hand end of its stroke and *C* at the opposite or right-hand end of its stroke. Steam from the steam-chest, *J*, is therefore entering the right-hand end of the main cylinder through the ports *E* and *H*, and the exhaust is escaping through the ports H^1, *E*, *K* and *M*, which causes the main piston, *A*, to move from right to left. When this *piston* has nearly reached the left-hand end of its cylinder, the valve motion (not shown) moves the valve rod *P*, and thus causes *C*, together with its supplemental valves *R* and *S* S^1 (which form, with *C*, *one casting*) to be move

from right to left. This movement causes steam to be admitted to the left-hand end

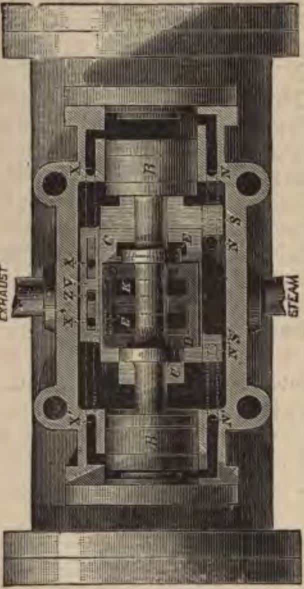


FIG. 23.—TOP VIEW OF STEAM VALVE CHEST AND VALVES, BLAKE PUMP.

of the supplemental cylinder, whereby its piston B will be forced toward the right,

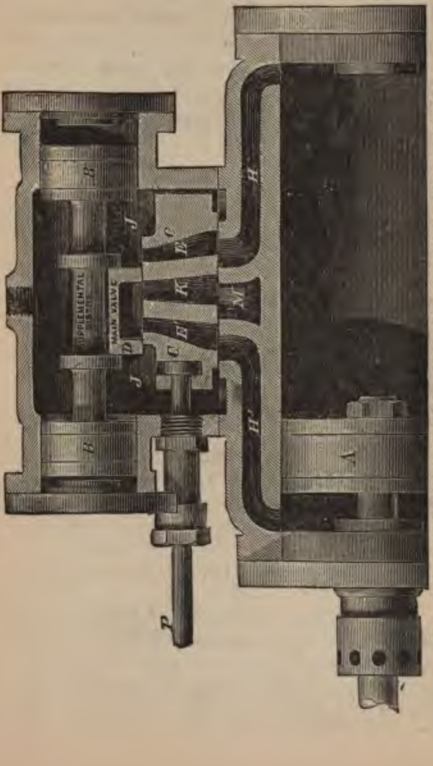


FIG. 24.—LENGTHWISE SECTION, STEAM END, BLAKE PUMP.

carrying *D* with it to the opposite or right hand end of its stroke; for the movement of *S* closes *N* (the steam port leading to the right-hand end), and the movement of S^1 opens N^1 (the steam port leading

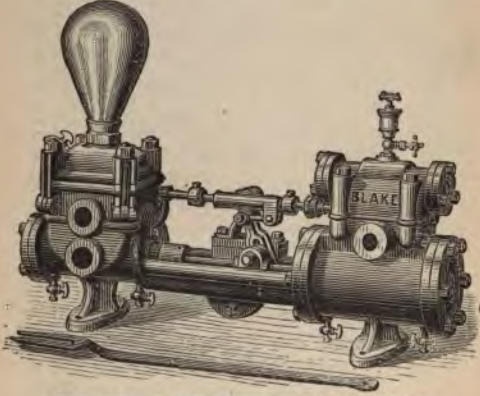
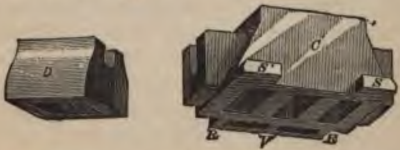


FIG. 25.—BLAKE DIRECT ACTING PUMP.

to the opposite or left-hand end), at the same time the movement of *V* opens the right-hand end of this cylinder to the exhaust, through the exhaust ports *X* and *Z*. The ports *C* and D now have posi-

tions opposite to those shown in the engravings, and steam is therefore entering the main cylinder through the ports E^1 and H^1, and escaping through the ports *H*, *E*, *K* and *M*, which will cause the main piston *A* to move in the opposite direction, or from left to right, and operations similar to those already described will follow, when the piston approaches the right-hand end of its cylinder.



FIGS. 26 AND 27.—VALVES OF BLAKE PUMP.

Q. What prevents the main piston *A* from striking the head of its cylinder?

A. The main valve has a *lead*, or, in other words, steam is always admitted in front of said piston, just before it reaches either end of its cylinder, even should the supplemental piston, *B*, be tardy in its action and remain with *D* at that end toward which the piston *A* is moving, for *C* would be moved far enough to open

the steam port leading to the main cylinder, since the possible travel of C is *greater* than that of D.

Q. What prevents the supplemental piston B from striking the head of its cylinder?

A. In its alternate passage beyond the exhaust ports X and X^1, it cushions on the vapor entrapped in the ends of this cylinder.

Q. How would you proceed to set up a Blake pump if the parts were all lying on the floor ready to be put together?

A. 1. Connect the steam and water cylinder castings by means of the center piece, screwing up the bolts hard. The joints between the flange of the center piece and the steam cylinder, as also the joint between the flange of the center piece and water cylinder, are ground joints. See to it that the faces of these joints are nice and clean before screwing up. If the faces are not in good order, reface them. If you have not time to do this, make joints of manilla paper.

2. Put in place each of the piston rod stuffing boxes, first by screwing in the seat (135). This is screwed in by a long

wrench having a T end, from the inside of the cylinder. Slip in the follower (134) and screw on the cap (133).

3. Now place the piston rod in the pump, after which bolt on the cross head (125). This is to keep the rod from turning while you screw on the piston rod nuts, etc.

4. Put on the steam piston, first placing on the head (136), then the packing rings (137), and then the follower (138). Screw up the follower bolts (139), after which fasten the piston rod firmly by screwing up hard on the piston rod nut (130).

5. Put the water piston (140) on to the rod, first slipping on the head (141); then the segments (145). Then slack up the set screws (146) by their keypins (147) and place the rings of canvas packing (144) in place, breaking joints. Then set out the packing with the set screws referred to, after which slip on the follower (142) and screw up tight with the follower bolts (143).

NOTE.—If it is a leather-packed piston, there are but three parts to the piston, not counting the follower bolts. Now screw on the piston rod nut (131).

6. We will now complete the fitting up of the water cylinder. The suction valve seats (50) will be found firmly driven into the water cylinder casting. In case new valve seats are to be fitted, drive them in with a block of wood over the face of the valve seat. Drive very hard. See that the seat and hole are perfectly clean before driving.

7. Now take the water valve plate (63), and after fitting in the valve seats same as above, slip on the valves, valve bolts and springs, Nos. 51, 52 and 53. Do the same for the suction valves. The lug bolts and nuts (60) should be put in position ready for locking down the water cylinder top (74). Now screw on the air chamber (61) and the try-cock (70). The drip plugs (65) should be screwed in the bottom of the water cylinder. Then place on the water cylinder head (69) and fasten on same with the bolts, and you have completed the water cylinder.

8. To complete the steam cylinder, take the steam chest or plunger cylinder (71) and fit it up complete with the plunger (auxiliary piston) (100). Before putting in the plunger, place in position its pack-

ing rings (101). Now put on the heads of the steam chest, screwing up hard with the bolts (68). Before placing the steam chest on the steam cylinder casting, fit in the valve rod stuffing box by first screwing in the seat (112); then slip in the follower (111) and screw on the stuffing box cap (110). The valve rod (104) should be slipped through the stuffing box seat before the latter is screwed in the casting. Now take the steam chest and turn it upsidedown; drop into place the main slide valve (102), the top part of which will fit around the center part of the plunger (100). Take the movable seat (103), which is a casting combining the auxiliary valves and the extension of the main steam and exhaust ports, and slip it on to the end of the valve rod. You now have the main valve and movable seat in position. Before placing these parts on the steam cylinder, slip on the valve rod, the valve-rod collar, and its parts (107, 108 and 109) on the end nearest the stuffing box. Then slip over the rod the sliding tappet (113), after which place in position the other valve rod collar.

9. Now fasten on to the water cylinder

casting the valve rod guide (105), securing it firmly in position with its bolt (106).

10. Place on the steam cylinder casting, the steam chest and the parts above named. Slide into the valve rod guide (105) the end of the valve rod. Before screwing down the steam chest, with its bolts (67), be sure and examine the face between the steam cylinder and the steam-chest. This is a ground joint, but if it is not in good order, make a joint of manilla paper, in case there is not time for refacing. If a joint of paper or rubber is used, be careful to cut the necessary holes in the same for the passage-ways to and from the auxiliary piston or plunger. This is sometimes overlooked, and the consequence is that the auxiliary piston fails to operate, and the pump will not work. It is well also to clean out thoroughly the small passage-ways referred to in the steam chest; also those in the main casting of the steam cylinder. Bad oil will often foul these passage-ways, so that the auxiliary piston or plunger will not properly operate; by screwing on the oil cup and drip cocks,

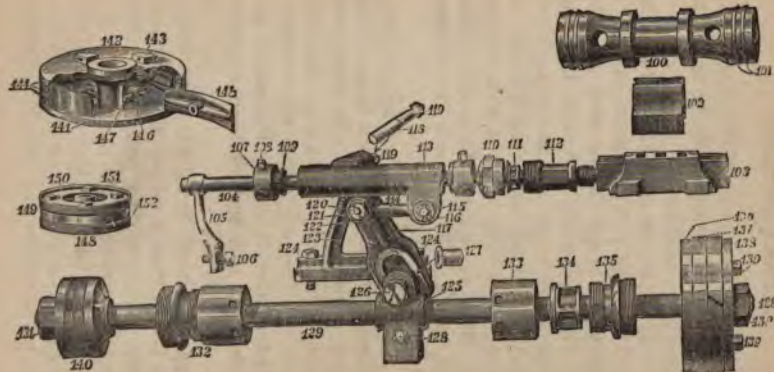


Fig. 28.—DETAILS OF BLAKE PUMP.

we have the steam cylinder complete. Proceed to complete the job by finishing the valve gear, as follows:

11. Slip into the crosshead (125) the pin (126). Now put on the roller (127). The pedestal (123) fasten down to the centre casting by the bolts (124). Connect the lever (117) to the top part of the fulcrum, first slipping in the fulcrum pin (118) and fastening it tight with its nut (119). Before placing the lever on its fulcrum pin (118), connect the former with the crosshead (125).

12. Now attach the sliding tappet (113) to the lever (117) by the link (114). The link pin (115) and split pin (116) will secure one end of the link to the sliding tappet. The other end of the link is attached to the lever by means of the link pin, nut and washer (120, 121 and 122).

NOTE.—One of the great advantages in the Blake pump is the ability to adjust the stroke of the pump by a very handy arrangement on the valve rod. (We refer now to the adjustable collars.) These collars can be turned around on a thread cut on the rod, so that the dis-

tance between them is lengthened or shortened at will, allowing more or less room for the sliding tappet, which means allowing the piston rod to make longer or shorter travel.

The set screw (108) locks and unlocks the collar. A turn on this set screw allows the collar to be moved freely on the valve rod. These collars can be adjusted as well while the pump is in motion as when at rest. An important convenience.

Q. What is the Bramah pump?

A. It is an oscillating pump, in which the piston occupies the diametral plane of the cylinder, in which it swings with an oscillating motion; there are two hinge valves in the piston, both opening from the suction towards the discharge; and there are in the cylinder two radial plates, each containing valves opening from the suction to the discharge; but these radial plates are about 30 degrees apart. When the piston moves in one direction, one of its valves closes and the other opens; then one of the valves in the radial plates, from which the piston is moving, opens and the other closes.

Q. What is the construction and operation of the "Bucket Plunger" steam pump?

A. It is on the inverted vertical type, having a crank and fly wheel driven by a Scotch yoke, the lower part of which is attached to the upper or smaller part of a Bucket Plunger. This style of plunger differs from the ordinary single acting plunger of uniform diameter, by making the lower part which works in the water cylinder double the area of that part which works through the stuffing box, and by an opening in the pump near the top of the water cylinder and above the discharge valve, the space around the smaller part of the plunger as it passes down into the water cylinder is filled, and on the upward stroke is discharged from the pump, and thus a steady stream is maintained, which cannot be done with the plunger of uniform size except two sets of water valves is used. Water for both the up and down strokes flows in through the suction valve when the plunger rises. The suction air chamber *J* is within the discharge air chamber *K*.

This pumping machine may be used as

a motor by withdrawing a tapered steel pin and thus disconnecting the pump plunger.

Q. How would you proceed to examine and take apart a bucket plunger pump?

A. To examine water valves, remove hand hole cover, and drive out tapering wedge that holds cage in place, when discharge valve and seat can be taken out. Suction valve can be taken out through opening made by removing discharge valve seat.

To remove water plunger, drive out tapering pin from lower yoke; take packing out of stuffing box; take out the bolts that hold body of pump to base; lift up the body of pump, and plunger will drop out.

To set or take up wear in slide box, loosen jam nuts on underside of yoke; loosen lower half *telescope* nuts; set pair of inside callipers to the proper distance yokes should be apart; run up lower *telescope* nut on bolt to proper distance, and follow up with jam nut underneath yoke. Care should be taken that the faces of yokes are parallel, or the box will bind and make the pump run unsteady.

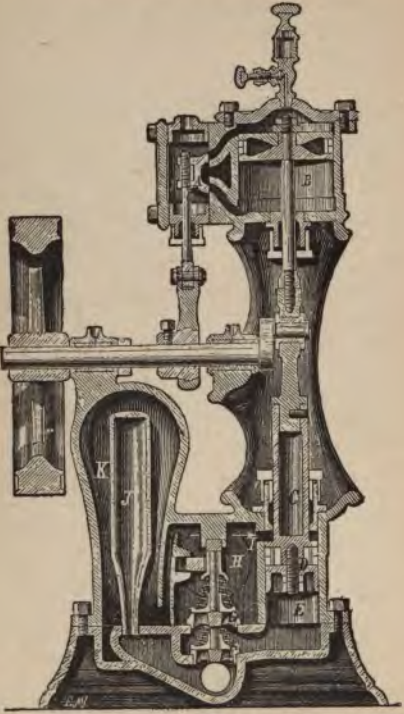


FIG. 29—*BUCKET* PLUNGER PUMP IN SECTION

To remove steam piston, drive tapering out of upper yoke; remove steam cylinder head; turn crank on upper centre; strike upper yoke a light blow to loosen piston rod from yoke, when steam piston and rod can be removed.

Q. Describe the construction of the Cameron pump?

Referring to the sectional cuts: Figs. 30, 31, 32 and 33, pages 98, 99, 100 and 101.

A. *A* is the steam cylinder; *C*, the piston; *D*, the piston rod; *L*, the steam chest; *F*, the plunger; *G*, the slide valve; *H*, a starting bar connected with a handle on the outside; *II*, the reversing valves, and *KK* the bonnets over the reversing valves; *N* is the body piece connecting the steam and water cylinders; *B* is the water cylinder with the valve chest bonnet removed; *M* is a valve seat shown in section (the valve over it being also shown in section); *T* is the discharge air vessel. Figure 2 shows a sectional view of the reversing valve chamber, with a phosphor bronze lining.

Q. What is the arrangement of pump valves in the Cameron steam pump?

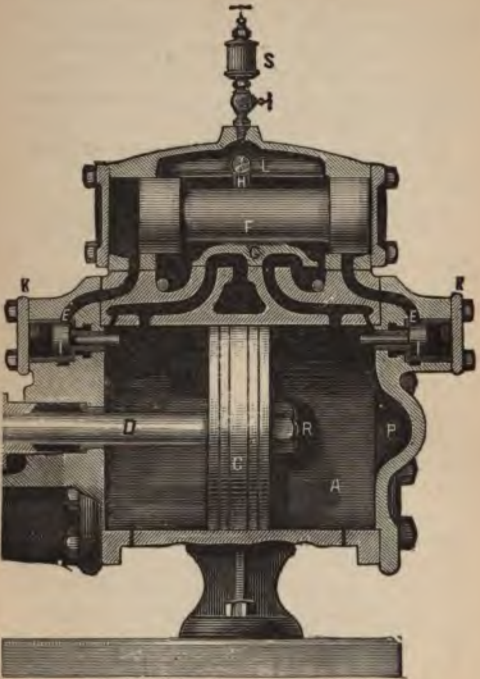
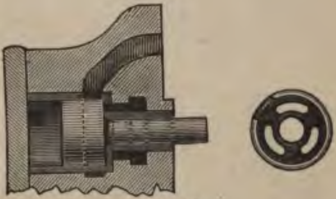


FIG. 30.—CAMERON STEAM END IN SECTION.

A. The cut shows the arrangement of the pump valves. Those on the right-hand side are shown full, and those on the left-hand side in section. The valve chest is bored out tapering, and the valve seats (made of brass) are forced in. The valves



SECTION THROUGH REVERSE VALVE I.

FIG. 31.—CAMERON REVERSE VALVE.

are removed by unscrewing the plugs on top, and pulling up the spindles. Those generally used are made of a casing of brass, filled with India-rubber, vulcanized, in its place. The rubber forms the valve face, and the metallic casing is intended to resist the pressure and protects the rubber from injury.

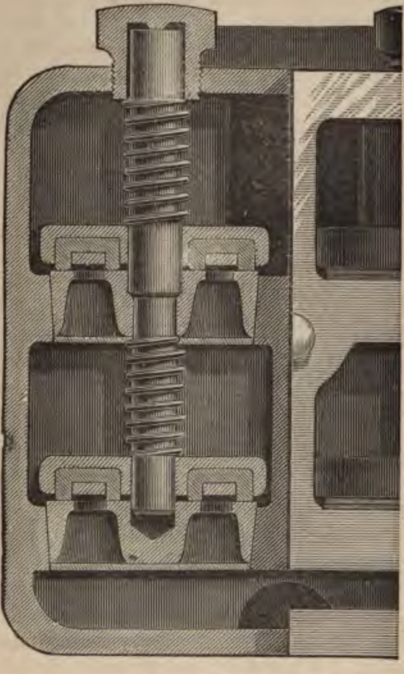


FIG. 32.—CAMERON WATER VALVE IN SECTION.

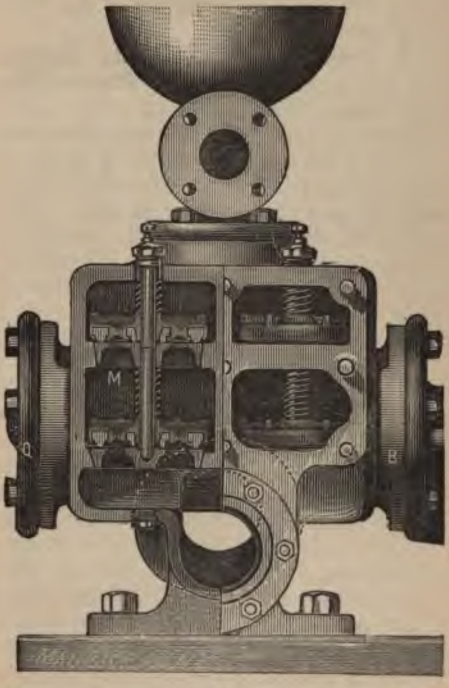


FIG. 33.—CAMERON WATER END IN SECTION.

Q. What is the operation of the Cameron pump?

A. Referring to the same cut: Suppose the steam piston *C*, moving from right to left; when it reaches the reversing valve *I* it opens this latter, and exhausts the space on the left-hand end of the plunger *F*, through the passage *E*, which leads to the exhaust pipe; the greater pressure inside of the steam chest changes the position of the plunger *F* and slide valve *G*, and the motion of the piston *C* is instantly reversed. The same operation repeated at each stroke makes the motion continuous. The reversing valves *I I* are closed by a pressure of steam on their larger ends, conveyed by an unseen passage direct from the steam chest.

Q. How may the Cameron pump be put together?

A. "There are no special instructions. The cylinders are brought in line by a connecting or bed piece, and all the other parts can go only in their proper places. Care is necessary in making new rubber joints, that the rubber is cut away for the steam passages, that the water piston is not packed too tight, and that in starting

cuttings or dirt are not blown from the steam pipe into the reversing valves chambers to interfere with the proper working of those valves."

Q. Describe the construction and operation of the steam end of the Carricaburu steam pump?

A. Refering to the four cuts given herewith: Figs. 34 and 35 represent longitudinal sections of both steam and water cylinders, and readily explain the whole arrangement. The principal feature is to be found in the valve, which is of the steam-actuated type. This valve, which is marked *F* in the cut, is moved by two small pistons, *G* and *G'*, working in special cylinders, as shown. The steam and exhaust ports for the pump cylinder are marked 4, 5, 6 and 7, while 10 is a port from this cylinder into a cylinder containing the valve piston *G*, and 8 a similar port to the cylinder containing the piston *G'*; 11 and 9 are ports between exhaust ports 5 and 6 and the cylinders *G* and *G'* respectively. Presuming the parts to be in the position shown, the steam is passing through the port 7 and the piston is moving to the

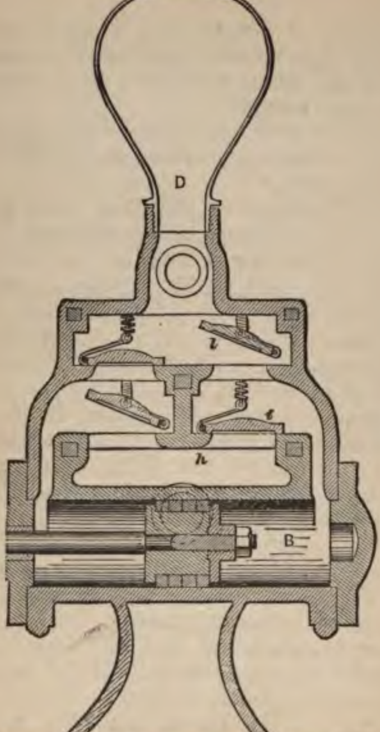


FIG. 34 —CARRICABURU WATER END, LENGTHWISE SECTION.

right, and the exhaust 5 is open by the valve to *M*. As soon as the piston *C* passes

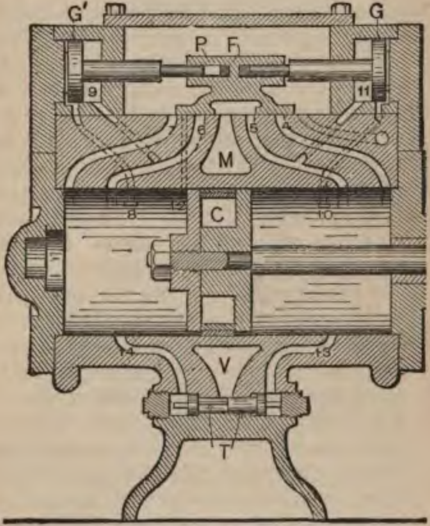


FIG. 35.—CARRICABURU STEAM END, LENGTHWISE SECTION.

or covers the ports 5 and 13, the steam in the cylinder is confined, and prevents

the piston *C* striking the cylinder head. The distance between the port 10 and the cylinder head is greater than the thickness of the piston, and the steam, therefore, enters the port 10 as soon as the piston uncovers it; while the piston is thus compressing the confined exhaust steam, the live steam passes through the port 10 and acts upon the piston *G*, moving it and the valve *F*. The port 7 is thus closed and the port 4, for admitting live steam to the cylinder, opened. The exhaust on the other side of the piston *C* is also opened by 6 to *M*, and the piston accordingly commences to move the other way. The exhaust of the steam decreases the pressure in the port 10, and the steam in the valve-chest, therefore, acting upon the rod of the valve piston *G*, drives the latter back before the main piston *C* uncovers the port 5, and then the steam coming through 5 and 11 holds *G* in place. The steam coming through 10 causes the pressures to balance at opposite sides of the piston *G*, and hence the latter remains in its normal position. The whole action is, of course, repeated at the other end of the stroke.

Q. If from any obstruction the valve should be moved just sufficiently to exactly cover both steam ports 4 and 7, what would prevent the pump from coming to a stand still?

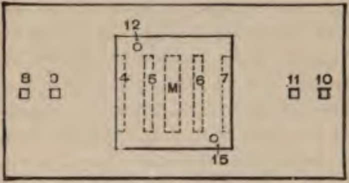


FIG. 36.—CARRICABURU STEAM VALVE AND SEAT.

A. The ports 12 and 15 (Fig. 36) are provided, passing down into the steam cylinder, and holes are drilled through the valve so that when the latter is in the position mentioned, these holes correspond with the ports 12 and 15, as shown in the top view of the valve and seat, and let steam into the cylinder. The steam will then act through the port 8 or 10 upon whichever valve-moving piston is to be moved further to complete the movement of the valve. The openings in the valve

F naturally correspond with the ports 12 and 15 only at the middle of the valve travel, and the ports are closed at all other times. It may be added that when the valve *F* is on its centre, and the ports 12 and 15 are open into the steam cylinder, if the steam piston *C* is covering one of the ports 10 or 8, and thereby obstructing the operation of the valve motion, the steam admitted by 12 and 15 will act upon the steam piston, moving it until the port 10 or 8, that had been covered, is uncovered and the steam, acting through this port upon the valve-moving piston, will remove the valve from its central position.

Q. How is water of condensation removed from the cylinder of the Carricaburu pump?

A. Beneath the cylinder is a small valve-chamber, *T*, which is tubular, and provided with caps at the ends and valves with triangular guide-stems in the smaller inner portion of the tubular chamber *T*. The combined length of the two valve-stems is greater than the distance between the seats for the valves, and there are ports 13 and 14 from the ends of the

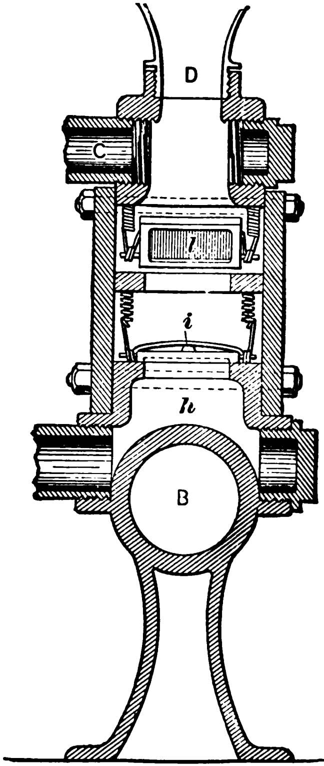


FIG. 37.—CARRICABURU WATER END, CROSS SECTION.

chamber *T* to the steam cylinder, and a lateral discharge pipe between the valve seats, which may be provided with a cock. When steam acts on one side of the piston *C*, the pressure closes the valve upon which it acts, opening at the same time the other valve, so that water of condensation can run off at the exhaust side from the cylinder. These operations are automatic, the valves closing and opening in opposite directions at each admission of steam to the cylinder. Two small blocks of wood or other similar material, one of them being marked *P* in the cut, are arranged in the valve *F* to act as buffers for the rods of the independent pistons *G* and *G'*.

Q. What are the peculiarities of the water end of the Carricaburu pump?

A. Mr. Carricaburu employs spring-valves which not only lift from their seats, but also swing to an angle, thus allowing an unobstructed passage of the water. The heads of the valve-chest are removable at either side to give access to the valves.

Q. How would you proceed to put together a Carricaburu steam pump if all the parts were separated?

A. 1. Place the valve on the ports.

2. Insert the valve pistons in their respective cylinders.

3. Bolt the heads on said cylinders.

4. Move the valve back and forth, over its travel, in order to push the pistons in their proper positions.

5. Leave the valve at one end of its travel ready to admit steam.

6. Replace the steam chest bonnet.

Q. What are the leading features in the steam end of the Davidson pump?

A. The peculiarity of the steam end of the Davidson pump is, that it has only one valve in the steam chest. This may be properly called a compound slide-valve with cylindrical face. It performs two duties, that of the ordinary slide-valve and of the auxiliary valve combined. Its duty as a slide-valve is, of course, to reciprocate across the steam ports, to admit steam alternately to the two ends of steam cylinder, and as an auxiliary valve, it is oscillated so as to open and close the steam ports that lead to the ends of the steam chest.

The steam chest is cylindrical and bored out to make a face for the slide-valve, and

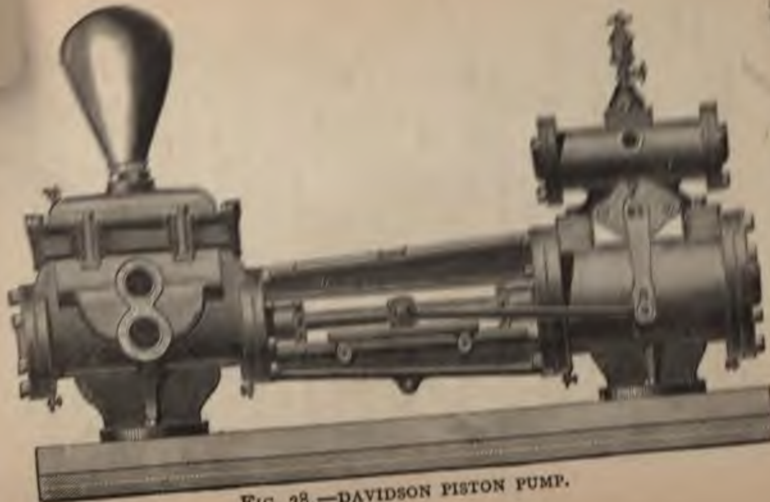


FIG. 38.—DAVIDSON PISTON PUMP.

to receive the pistons that assist in operating the valve. The pistons are connected together, sufficient space being allowed between them for the valve and steam ports, and they are also connected to the

FIG. 39.—CROSS SECTION, DAVIDSON STEAM CYLINDER AND VALVE.

slide-valve, all working in the same plane and being of same diameter, thus insuring evenness of wear and readiness of access for adjustment, repairs, etc. The valve is oscillated by an oblique cam, connected with the valve by a steel pin passing through the valve into the exhaust port,

in which the cam is placed. The moving of the valve does not depend entirely upon the steam admitted to the end of the valve piston, for, should that not be quick enough to operate on the valve, with the pump under a high rate of speed, the cam is so constructed that it will carry the valve mechanically, and thus prevent the piston from striking the cylinder heads in anv case.

Q. How would you proceed to set up and adjust a Davidson pump if all the parts were separated?

A. 1. Should the steam and water cylinders and intermediate frame be separated for shipment, the person erecting the pump must carefully wipe all joint faces and place the face packing in position.

2. Select all bolts for their places, and by lining the cylinders to the marks, all parts will draw in line as they are screwed to a tight joint.

3. The steam chests are always shipped with the steam cylinders on the regular sizes, and in the special and larger sizes are so fitted and marked that the operator *can easily* line the chest with its cylinder.

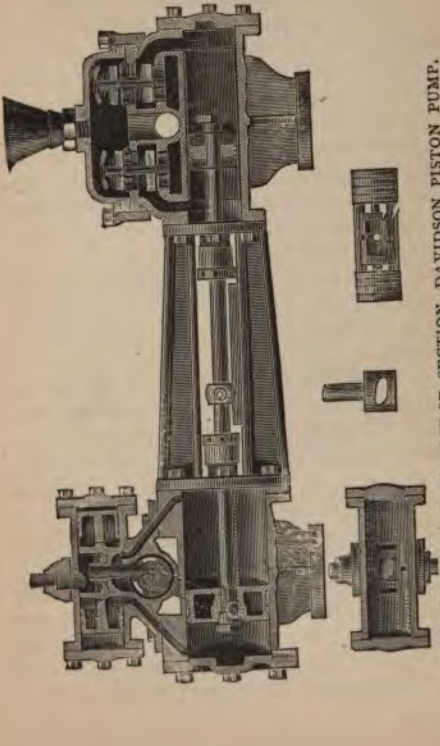


Fig. 40.—Lengthwise Section, Davidson Piston Pump.

4. When the cylinders and intermediat are bolted together, it is best to plac these parts on the foundation, then pas the piston rod through the stuffing boxes

5. By passing the rod to the extrem end of the water cylinder, the follower and cup packing can be pushed on to th rod, and guided into the bore of the bar rel, the cups being first softened an drawn into form by the former that i sent with each pump.

6. This packing should be moderatel slack at first, as it will immediately swell when submerged in the fluid to b moved.

7. After the pump piston is drawn t place by the nut and special wrench move the piston and rod to the other ex treme stroke and enter the spring rin steam piston, then draw the same t place.

8. Place a small amount of packing i each stuffing box, and then traverse th rod and piston forward and backward and note point of the bearing of the glands on the rods; if any, then screw the glands on again to about half posi 'on, and screw the pump to place.

9. Then move the pistons as before, and if all is free the pump is in line on the foundation; but if the rod is marked by a rubbing contact the pump has been drawn out of line by screwing it down.

10. In the latter case, the nuts on the foundation bolts must be at once slackened, and thin packing inserted under the lugs or feet.

11. Of course the foundation bolt holes must be marked from a template or the pump itself then drilled and the bolts dropped into them before the pump is finally placed on the top foundation stone; they are then held in position by melted sulphur being poured around them.

12. The steam valves and movements for same, are fitted to gauges, and therefore invariably go to their places without trouble.

13. The throw piston and its centre section or main valve will enter from either end, and the cam will roll into connection with the driving pin (which enters from the top) with ease, as the steadying sleeve is so fitted as to bring all parts of the valve gear in line.

14. The cam is of steel, hardened, also

the driving pin, and requires no adjustment at this point, as the stroke can be adjusted for the wear that may take place by the sector and slot at the valve lever.

15. The cross-head is firmly fixed to the piston rod by a set screw, and is also marked to position, and the cross-head is thus adjustable to alignment to the guide which supports its outer end, wear being provided for, by a brass gib fastened to place by a screw.

16. At the steam end, proper holes are drilled for liberal sized drip cocks, and these must in all cases be piped in the most direct manner and connected to a trap if there is one within a reasonable distance.

17. The steam pipe to all steam pumps should enter a small receiver before connecting to steam chest, in order to collect the water from condensation, this water being conducted to the trap.

18. The above method will insure dry steam, and prevent water hammer on the steam valve and piston.

19. The exhaust should be carried away in a pipe as free from elbows as possible, and both steam and exhaust

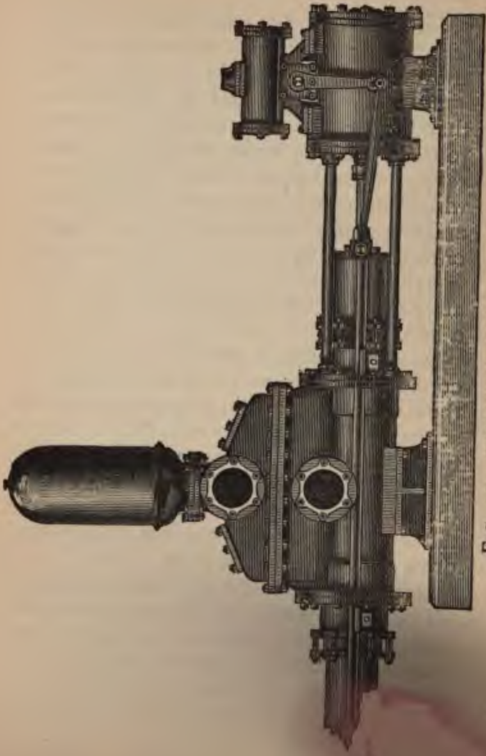


FIG. 41.—DAVIDSON PLUNGER PUMP.

pipes must have a union joint, say two feet above the joints on the cylinder, for convenience in repairing.

20. At the water end it will be found that the suction valve seats are screwed to their position, while the delivery valve seats are drawn to theirs by the stems which are common to both. The spring and the rubber valves being first slipped onto the stems.

21. For cold water there is a moderately soft rubber valve, and for hot water a hard one.

22. The suction pipe must always be connected with care. If a high lift on the suction is required, paint all joints after screwing up, and if there is trouble in getting and holding the water, first examine the rubber valves and their springs, then the suction pipe, by holding the flame of a lamp to each joint, and any leakage will draw in the flame.

23. On the suction pipe or chest should be placed a half-inch angle check valve and stop cock, in order to supply the air chamber at any time that an extra amount of absorption may take place at the air chamber, by the moving column of water.

24. Finally, in starting always clear the steam end of all water of condensation, and run with the drip cocks open, at a very slow speed for the first five minutes.

Q. Describe the construction and operation of the Dean Bros. steam pump valve gear?

A. Fig. 41 is a vertical section through centre line of cylinders. Figs. 42 to 47 show the steam valve gear in detail. Fig. 48 shows the pump in perspective. The operation of the steam valve gear is as follows: The main slide valve has a lug on its back which fits into the auxiliary piston *E*. The valve is carried back and forth by said piston. The auxiliary valve *F* slides on the valve seat *E2*, and is provided on its underside with the diagonal exhaust cavities *d d*. The valve-rod *F1* is secured to the valve *F*, and has its outer bearing in a stud *F2*, fastened to a post *F3*, bolted to the main frame of the steam pump. The ports *b b1* and *c* are arranged in the shape of a triangle on the face of valve-seat *F1*, and the diagonal cavities *d* and *d*, on the underside of the auxiliary valve *F* diverge from each other, whereby the cavity *d*

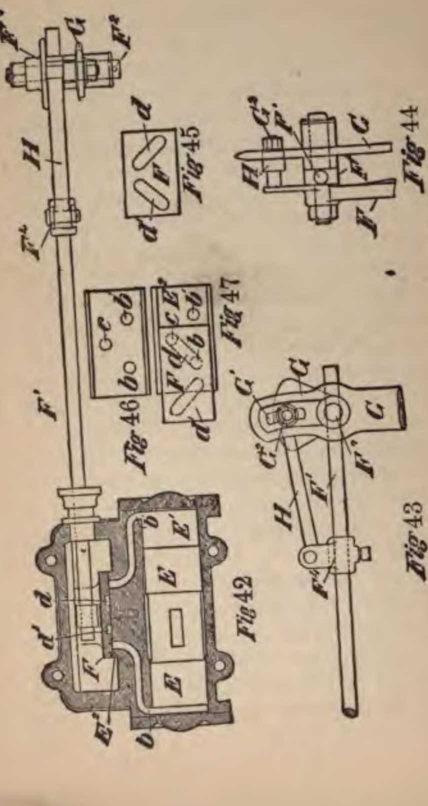


FIG. 42 TO 47.—DEAN BROS. PUMP, DETAILS OF PARTS.

connects the ports *b* and *c*, and the cavity *d* connects the ports *b* and *c* when the auxiliary valve *F* is in extreme positions. The operation is as follows: When the main piston moves from left to right, the auxiliary valve *F* is moved in an opposite direction by the valve-rod *F*1 and connecting link *H*, attached to the upper part of the lever *G*, which is actuated by the piston rod carrying the lower end of the lever *G* with it in the movement to the right. The auxiliary valve *F* opens the port *b*1 to admit steam to the sub-cylinder *E*1 at the moment the main piston has reached the limit of its stroke, whereby the auxiliary piston *E* is forced to the left, thereby opening the main port and admitting steam to the cylinder, and consequently reversing the movement of the main piston. On the return stroke of the main piston the piston rod swings the upper part of the lever *G* to the right and thereby reverses the movement of the auxiliary valve *F*, whereby the port *b*1 is closed, and at the moment the piston has reached the limit of its outer stroke the port *b* is opened by the valve *E*, and steam admitted to the other end of the

sub-cylinder *E*1, causing the auxiliary piston *E* to reverse its motion, thereby opening the main port to admit steam to main cylinder at its outer end, whereby the movement of the main piston is again reversed. By this continuous movement of the auxiliary valve *E*, the ports *b* and *b*1 are kept closed, except at the end of each stroke; at the moment the main piston *B* is reversed, and as soon as the main piston *B* begins its returning stroke the auxiliary valve *F* closes the ports *b* and *b*1 respectively. This prevents any waste of steam in case the auxiliary piston *E* is worn enough so as to leak, as the ports *b* and *b*1 are closed. When the auxiliary valve *F* is in its extreme outer position and the port *b*1 is open to admit steam, as shown in Fig. 7, a connection is established between the port *b* and the exhaust port *c* by means of the diagonal cavity *d* in the under side of the auxilary valve *F*, and when the valve *F* has shifted to its inner extreme position, the port *b*1 and the exhaust port *C* are connected with each other by the diagonal cavity *d*1 in the bottom of auxiliary valve *F*. This arrangement admits of a short valve with

a long stroke, which stroke is derived from the full stroke of the piston rod acting on the lower forked part of the lever *G*, which imparts a reciprocating motion to the valve rod *F* by means of connecting link *H*. The stud *G2* being adjusted up or down in the segmental slot *G1* of lever *G*, increases or diminishes the travel of the auxiliary valve *E*. If the stud *C2* is adjusted up in the slot *G1*, the travel of valve *E* is increased, and ports *b* and *b1* opened carlier, causing the main piston to shorten its stroke, and if the stud *G2* is moved down in slot *G1* the travel of auxiliary valve is diminished, the ports *b* and *b1* opened only at the end of the movement of lever *G*, thereby increasing the stroke of the main piston.

The adjusting of stud *G2* up or down in slot *G1* does not change the relative position of the ports *b*, *b1* and *c* with the diagonal cavities *d* and *d1* in auxiliary valve *E*, as the slot *G1* is segmental, the link *H* being the radius.

The auxiliary valve and its rod have a continuous motion similiar to that given by an eccentric, the auxiliary valve having a long stroke and rapid motion,

and keeps the ports leading to the auxiliary piston closed, except at the moment the main piston is being reversed, thus

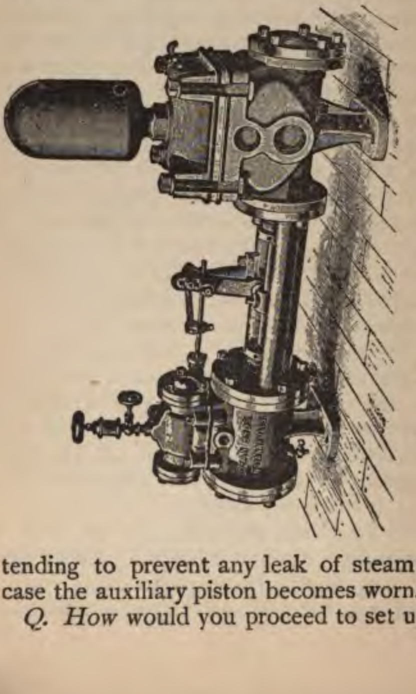


FIG 48 —DEAN BROS. PISTON PUMP.

tending to prevent any leak of steam in case the auxiliary piston becomes worn.

Q. How would you proceed to set up a

Dean Bros. pump, supposing all parts to be separated and laid upon the floor ?

A. 1. Bolt the steam and water cylinders to cradle, being very careful that there is no dirt nor bruises on face of flanges.

2. Put steam piston head (without the ring) on piston rod, slip the rod into place, passing it through the glands and cross-head. Put water piston on rod; move the piston rod back and forth, seeing that the rod moves freely and does not bind; if it does there is something between the flanges, or the rod is sprung, or the heads are out.

3. Put valve rod and valve motion in place; put steam chest on steam cylinder; screw the valve stem stuffing box nut tight so it cannot move. Loosen set screw in cross-head, and move cross-head to one end of stroke; make scratch on valve rod close to stuffing box nut; move cross-head to other end and make another scratch on valve rod.

4. Remove steam chest; turn it upside down so the valve and seat can be seen, and set small valve so that when left-hand scratch on valve rod is close to stuffing box, the left-hand part is open, and

when right-hand scratch is close to nut, right-hand part is open the same distance.

5. Put slide valve in steam chest; turn the chest over on to a smooth piece of shingle, or board, or carpenters square, to keep valve from falling out when steam chest is being replaced on cylinder.

6. Place packing rings in piston head; screw the nuts tight; put on cylinder heads; see that all nuts and screws are tight.

Q. What is the construction of the Deane direct acting steam pump?

A. In the Deane patent steam pumps the tappet arm 11, which is carried by the piston rod, comes in contact with the tappet when near the end of its motion, and, by means of the valve rod 24, moves the small slide valve which operates the supplemental piston 9. The supplemental piston, carrying with it the main valve, is thus driven over by steam, and the engine reversed. If, however, the supplemental piston fails accidentally to be moved, or to be moved with sufficient promptness by steam, the lug on the valve rod engages with it and compels its motion by power derived from the main engine.

Q. Can a Deane pump run vertically?

A. Yes; the supplemental piston being driven by mechanical action from the main piston.

Q. Give detailed instructions as to taking down, examining and putting together a Deane steam pump?

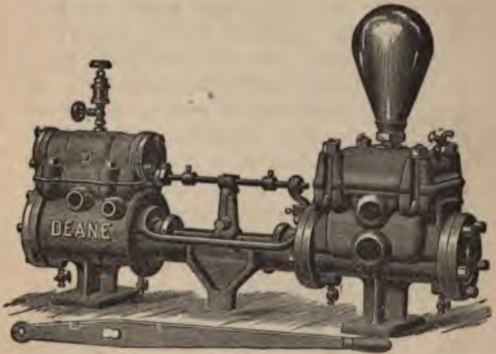


FIG. 49.—DEANE PISTON PUMP.

A. The sectional view, the detail view of parts, and the accompanying "list of parts" give information that will enable any intelligent mechanic to take apart, repair and put together again any of these

machines. In regard to the water cyli
der, marked 2 in cut, 27 is the piston, 1
is the water valve plate, above which a
the discharge valves, and below it the su
tion valves. To examine the discharg
valves, loosen the nuts 26 on the ey
bolts, swing down the bolts and remov
the water cap 13. The proper positio
of the parts is shown in the pump cu
Parts in detail are shown at Nos. 48 t
52 in detail cut. 48 is the valve seat. I
is made of composition metal, and is s
cured to the plate by a taper fit. In r
placing these seats, it is not necessary t
drive them down to the shoulder. Driv
them in squarely and moderately tigh
Above the valve is a metal plate No. 5
on which the valve spring 50 bears, pr
venting injury to the upper face of th
valve. Spring is held down by the ste
49. Care must be taken in replacin
valves to screw these stems in tight, s
that valves will not get loose, and th
stems, etc., get into the pump.

Construction of suction valves is th
same as above described. To reach th
suction valves, remove the valve plate 1
*In rep*lacing valve plate and cap, ca

must be taken to use gaskets of good rubber, and see that they are cut so as to

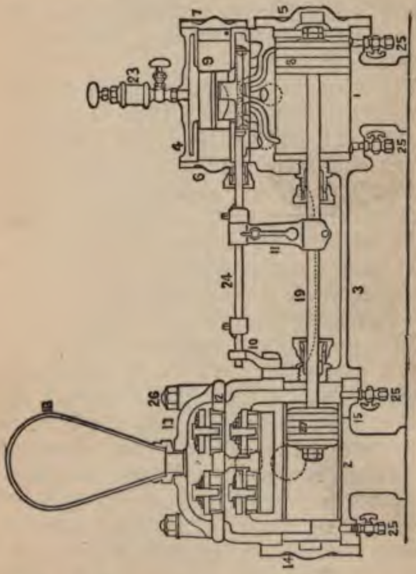


FIG. 49.—DEANE PUMP, PARTS MARKED IN DETAIL.

cover the exact form of the cap where it bears on the plate. The water piston is,

in regular pumps, fitted with fibrous packing.. When this becomes worn it can be replaced by removing piston rod nut 31, taking off follower 45, taking out the worn packing and replacing the new as shown in 47.

To examine the steam valves, remove the nuts holding down the valve chest and lift it from its place. See that both valves and their seats are in proper condition. If not, they can be readily faced with a scraping tool, as they are plain slide valves. To remove the valve piston, take out the screw in the side of chest, remove the chest head 7 and it can be readily taken out.

In replacing the valves and chest, cut out a gasket of good thick calendered paper. This is better than rubber for steam joints, because it will not burn or give under action of hot steam. See that there are 4 square holes cut in it to match the ports between the chest and cylinder. Then put the main and auxiliary valves in position in the chest while it is lying open side up. Then lay a thin straight edge across the chest to hold valves in, invert *the chest* and place it on the pump.

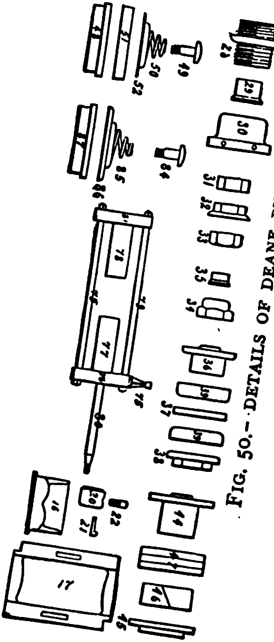


FIG. 50.—DETAILS OF DEANE PUMP.

Finally raise the chest a trifle and withdraw the straight edge.

The steam piston is similar to that of an engine. It needs no special explanation. Seldom requires examination. In running the pump see that the lubricator 23 is well supplied with good oil. Oiling is especially desirable just before stopping.

In starting the pump, the air cock on the water cap should be opened to release any air that may be entrapped there. Drip cocks 25 should be opened in the steam end in starting, and on both ends in stopping, especially if in season and situation where there is danger of freezing.

The tappet arm II is secured to piston rod 19 in such position that a dowel pin in the arm enters a corresponding hole in the rod. The tappets 20 fit over the keys 21. These keys fit in slots cut in the valve rod in the proper places. These are cut to gauge at the works, and need no change. The steam valves may go into the chest either way around in regular pumps, as both ends are alike. All stuffing boxes should be well filled with packing and screwed no tighter than necessary to prevent leakage.

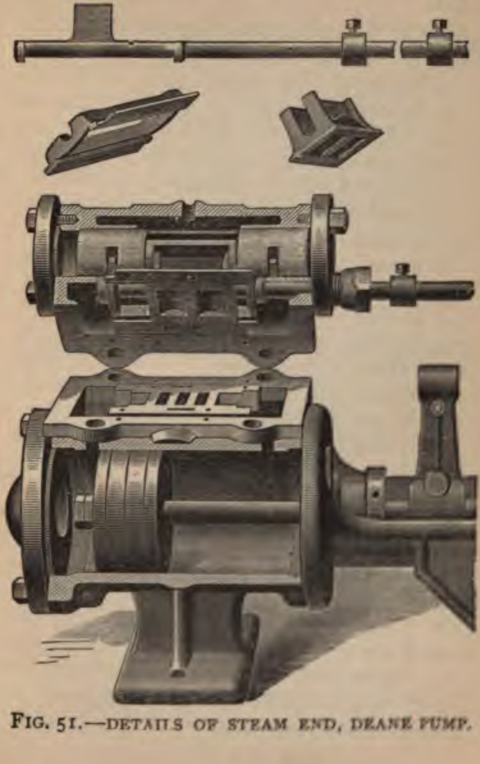


FIG. 51.—DETAILS OF STEAM END, DEANE PUMP.

PARTS OF DEANE'S STEAM PUMPS IN DETAIL.

LIST OF PARTS.

1. Steam Cylinder
2. Water Cylinder.
3. Yoke.
4. Valve Chest.
5. Steam Cylinder Head.
6. Inside Valve Chest Head.
7. Outside Valve Chest Head.
8. Steam Piston.
9. Valve Piston.
10. Guide.
11. Tappet Arm Complete.
12. Water Valve Plate.
13. Water Cap.
14. Water Cylinder Head.
15. Water Cylinder Lining.
16. Main Valve.
17. Auxiliary Valve.
18. Air Chamber.
19. Piston Rod.
20. Tappet.
21. Tappet Key.
22. Tappet Set Screw.
23. Lubricator.
24. Valve Rod.

25-25-25-25. Drip Plugs or Cocks.

26. Eye Bolt and Nut.
27. Water Piston (see Nos. 44 to 47)

SEE PAGES 131 and 133.

28. Bushing. 29. Gland. 30. Cap.	For Piston Rod Stuffing Box.
31. Nut. 32. Flange Nut. 33. Check Nut.	For Piston Rod.
34. Cap. 35. Gland.	For Valve Rod Stuffing Box.
36. Water Piston. 37. First Follower. 38. Second Follower.	For Leather Cup Packing.

FIG. 52.—DEANE VALVE.

39-39. Leather Cup Packing.	
44. Water Piston. 45. Follower. 46. Inside Ring, etc. 47. Fibrous Packing.	For Pat. Fibrous Ring Packing.
48. Seat. 49. Stem. 50. Spring. 52. Cover.	For Rubber Water Valve.

51. Rubber Water Valve.
75. Tappet Arm.
76. Inside Cross Head.
77. Inside Plunger.
78. Outside Plunger.
79-79. Side Rods.
80. Piston Rods.
81. Outside Cross Head

For Double Plunger Pumps

84. Stem.
85. Spring.
87. Seat.

For Metal Disc Valve.

86. Metal Disc Valve.

Q. What is the construction and operation of the Delamater single steam pump?

A. In the Delamater single steam pump the main valve is entirely moved by steam, and is what is known to the tra le as a "steam moved valve." The cut shows the main valve, with a piston on each end of it. This piston is packed with spring rings. The steam and exhaust are admitted to the proper end of these pistons by a small auxiliary valve. This latter is cylindric, and is oscillated from one side to the other by a cam on the valve stem. This cam is worked by an arm from the piston, and as

the piston reaches one end, it turns the auxiliary valve into a position which admits live steam from the boiler to one end of the main valve, and exhausts the steam from the opposite end. This allows the steam to drive the main valve over to its opposite position, and reverses the motion of the main piston.

Q. What are the instructions as regards the adjustment of the Delamater single steam pump?

A. If the pistons run to one end, and remain there, either some accident has happened to the cam, and it has been forced out of adjustment, or the exhaust pipe has become stopped up. The cam on the valve stem, may be adjusted by turning it slightly on this valve stem; the proper direction will be found by one or two trials.

Should the pump work unsteadily or *hitch* in its motion, the chances are much in favor of the water piston's having been packed too tight; or possibly having been packed with dry packing, which swells very much after the pump has been started and the water allowed to soak into it.

Should the pump *pound* in the water

end, it is usually caused by the springs on the water valves becoming weak, and they should be replaced by stiffer ones.

Nearly all of the direct acting steam pumps will work the condensed water from cold pipes through them if you will wait

FIG. 53.—DELAMATER SINGLE PUMP.

sufficiently long for them to do so. But if it is essential to start quickly, this can be readily done in the Delamater pump by first placing the arm which has the rollers on it in the middle of the cam; that is, somewhere between the two in-

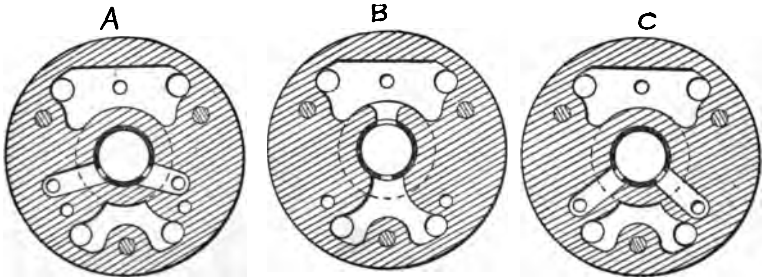


FIG. 54.—DELAMATER STEAM VALVES, THROUGH A. B AND C, OF FIG. 55.

clines, or in such a position that you can move the cam by hand. This will allow

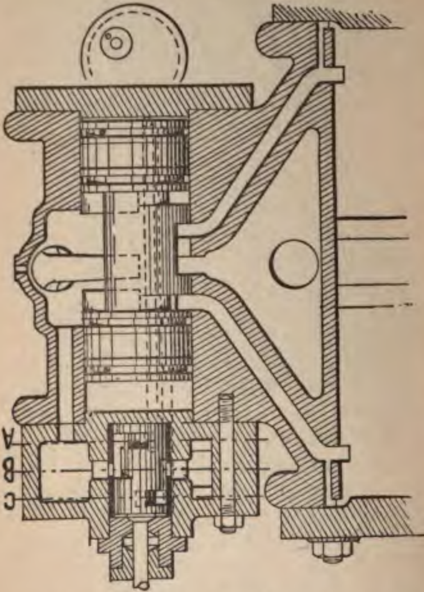


FIG. 55.—DELAMATER STEAM VALVES AND PARTS.

you to move the auxiliary valve first in one position and then in the opposite.

The handle on the side may then be used to move the main valve, which will force the water from the main valve chest out to the exhaust. The operation is: First, turn the cam and auxiliary valve in one direction, then try with the handle which is the easiest way to move the main valve. One way will be found easy, and the other way—the boiler pressure being against you—it will be found almost impossible to move it in that direction. Now, by the handle on the side, move the main valve over to the end of its stroke; let it stand there for one or two seconds; then reverse the cam and auxiliary valve, and move the main valve in the opposite direction to the end of its stroke. If you will do this once or twice it will clear the pump of water in about four seconds' time—when it will run along at its regular gait.

To remove the water valves, unscrew the brass cap on the outside of the water cylinder, and remove the brass spindle which goes through two valves and their seats—these valves being arranged in pairs, one suction valve below one discharge valve, always, and [illegible] le passing through both val[illegible]

It sometimes happens in piping-up these pumps that the pipe fitter makes an error, and puts his exhaust pipe where his steam pipe should be, and *vice versâ*. The proper position for these pipes is—that the steam pipe comes in at the opening at the top of the steam-chest, and the exhaust at the opening near the bottom of the steam-chest. This error has been known several times to occur, and, strange to say, this pump will work when piped-up in this manner—although far from satisfactorily.

Q. What is the construction and operation of the Delamater duplex pump; and what are the instructions as regards adjusting it?

A. The Delamater duplex pump is arranged similarly to nearly all others, that is—the piston on one side operates the valve on the other side. These valves are flat slide valves, and there is nothing in the steam-chest but the slide valve before mentioned and the "toe" which works it. Should anything happen, we advise removing the steam-chest covers, and an inspection should instantly show where the trouble is. I cannot

imagine what *could* happen to such a style of steam cylinder; but would say, however, that should anything be broken, and it should become necessary to reset these valves, the proper plan is to place the pistons in the center of their strokes, place the valves in *their* "central position," and fasten the arms while in that position.

FIG. 56.—DELAMATER DUPLEX PUMP.

This is all the setting that is necessary with any of these valves.

The water ends vary in construction, but are usually made of the plunger type,

and should the pump refuse to make its stroke, or one side make more than the other, it will generally be found that the stuffing-boxes on one side are packed too tightly, or that the plungers have become cut by some grit or foreign substance having worked in.

These pumps start very quickly, and will work the water of condensation out provided the exhaust pipe does not run up too high, as it is sometimes run up inside of a high chimney. In this case, as well as in setting all other pumps, the pipes should be arranged with drain cocks, so that this condensed water can be drawn off, both from the steam and exhaust pipes, without having to be forced out by the pump through the exhaust pipe.

Q. What is the construction of the Guild & Garrison direct acting steam pumps?

A. These pumps for general service are made in three general styles, called by the makers the "Regular," the "Metal Valve" and the "Plunger."

The difference between these styles is in the construction of the pump end of

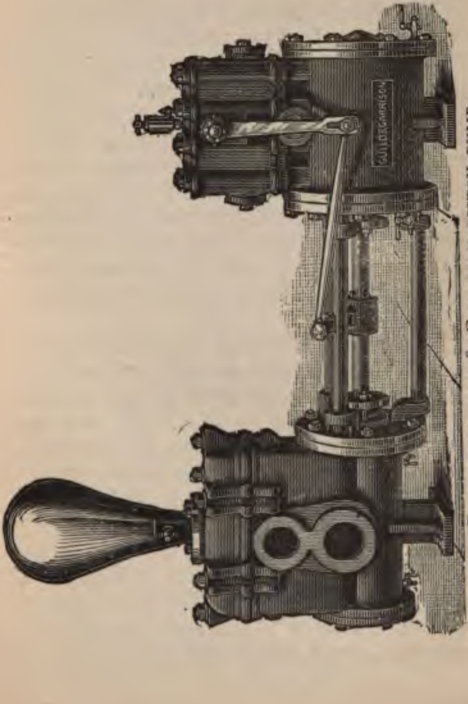


FIG. 57.—GUILD & GARRISON PISTON PUMP.

the machine—the steam ends being alike in all cases.

The cut shows the "Regular" pattern. The pump valves are all above the pump barrel, the suction valves being carried in the main cylinder castings. The discharge valves are upon a removable plate immediately above the suction valves. This plate is called the discharge valve plate, and the casting which rests upon it, and also carries the air vessel, is called the discharge valve box. The valve seats are circular in form, and are screwed into their places. These seats are made to gauge.

The pump piston is made either with metal ring, fibrous or leather packing. The leather packings are furnished, formed and cut to shape ready to put into the piston. For boiler feeding, the piston is fitted with a metal packing ring.

Q. Describe the steam end of the Guild & Garrison pumps?

A. Motion of the steam valves is taken from the piston rod, through the medium of a rock shaft, to which is keyed a lever; a link connects this lever with an arm, which is keyed to the piston rod. In the

steam chest are two steam valves—one of which is called the main steam valve; the other, which is much smaller and moves beside it, is called the auxiliary steam valve. Secured to the top of the main steam valve, and moving with it, is a double-ended plug or piston, called the valve driver.

If you will remove the cover of the steam chest and give a few moments examination to the internal parts, you cannot fail to understand their purpose and arrangement.

You will notice first, that the movement given by the arm on the piston rod causes the main steam valve to move positively a large portion of its travel. To complete the travel, the auxiliary steam valve, which is moved positively its entire travel, opens a passage-way to exhaust steam from one end of the valve driver, and opens another to admit steam pressure to the opposite end; the result is that the valve driver is driven over and carries the main steam valve, thus reversing the motion of the main steam piston.

The auxiliary steam valve is a "D" valve, and its action is precisely the same

as a D slide valve in a steam engine, and its effect upon the valve driver is exactly the same as if it was a piston of a steam engine.

Both main and auxiliary steam valves having plain, flat faces, they are easily faced up when found necessary.

Q. To take out the valve driver, what must be done?

A. Take off the small plate at the end of the chest, disconnect the link, raise the chest and swing the rockshaft clear; the driver can then be removed.

Q. If at any time you wish to take out the main steam valve, how should you proceed?

A. Take off the nuts on top of the chest and raise the chest high enough to take the valve out from below it.

Q. To remove the auxiliary steam valve, what is the course?

A. Take off the chest cover, disconnect the link, and swing the rockshaft toe clear of the valve; it can then be lifted out.

Q. Should the driver, in course of time, become leaky, what is the better plan?

A. To send to the makers for a new one. These are finished ready to be put into the chest.

Q. If the piston runs hard up against one head of the cylinder, and does not touch the other, of what is this evidence?

A. That the arm has shifted on the piston rod. All you need do is to put the arm back to the original marks on the rod and drive up the keys.

Q. If the piston strikes both heads of cylinder, what then?

A. Raise the link in the slotted end of the lever, about $\frac{1}{2}$ an inch; this will shorten the strokes.

Q. When the pump becomes old and sluggish in action at the end of the stroke, what do you do to remedy this?

A. Take out the auxiliary valve and lengthen the cavity on the face of it about 1-32 of an inch at each end.

Q. How can you do this?

A. With a file or narrow cold chisel, without the aid of a machinist; you will find lengthening the cavity will cause the pump to be as "lively" as a new pump.

Q. When steam is first turned into the pump, considerable of it will be condensed; in some cases water is carried over in steam-pipes and there will be water enough to fill the cylinder and chest, what will be the effect?

A. To make the first few strokes of the pump slow, until the water is thrown or carried out.

Q. If you are in a hurry, in case of fire, for instance, how can this water be thrown out instantly?

A. By moving the main valve directly by hand, a supplemental lever and rock-shaft being provided for that purpose.

Q. What care should be taken in handling the discharge valve plate?

A. That the rubber gasket that forms the joints between it and the pump cylinder be not cut or torn. When putting the plate in its place, have the surface clean, particularly across the diaphragm that divides the two suction chambers.

Q. Why?

A. Because a leak at this place is a serious thing; it very materially reduces the suction power of a pump.

If you have the "metal valve" pattern of pump, take the same care about the joint surfaces, between valve plate or bonnets, and pump cylinder.

Q. Should you have occasion to make new gaskets, is there any precaution necessary?

A. Be sure and cut them so that the diaphragms will be well covered.

Q. If you are pumping very hot water, or a volatile liquid, with the metal valve pattern of pump, is there any special precaution recommended?

A. Be particular to keep the springs on the valves well "set up," so as to make the valves close quickly at the end of each stroke of the pump.

Q. If after a time the springs become slack, what must you do?

A. Remove the valve cover or bonnet, take out the valves and springs, and put more "set" in the latter, by a file, cold chisel, or screw driver pushed under the springs, bending them up slightly.

Q. In course of time, when the metal packing has worn so that the piston will leak, what is to be done?

A. The first thing to do is to take off the back head of the pump cylinder, and examine into the condition of the bore of the cylinder; if it is found to be still quite true and round, then put in a new metal packing ring. These are furnished turned to fit.

Q. But if, as will be [illegible]

case, after long service, the bore is worn out of true, what is to be done?

A. Then your remedy is to remove the ring, which is easily done by taking off the follower of the piston (*i. e.*, the plate at the back of the piston); the ring can then be taken out, and the space left will be found just right to pack with any of the soft square packing in the market, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$ and $\frac{3}{4}$ sizes, as the diameter of piston may determine. If these are not at hand, braid up some hemp and pack with that.

Q. What is the distinguishing characteristic of the Gwyn pump?*

A. A "whirpool chamber," in which the water continues to rotate after having passed out from the pump.

Q. By whom was the whirlpool chamber invented?

A. By Prof. James Thomson.

Q. What are the peculiarities of the arms of the Gwyn pump?

A. They diminish in width as they recede from the centre.

Q. What is the object of this?

A. To make the water flow more smoothly

---

* *Practically* the same as the "Webber" or "Lawrence" pump.

Q. What is the construction and operation of the Hall duplex steam pump?

A. The sectional cut illustrates the interior arrangement and construction of the steam valves, water cylinder, etc. The operation is as follows: The engine

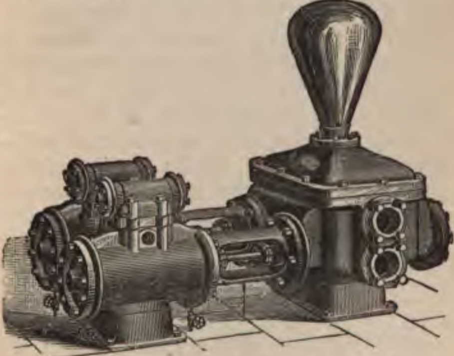


FIG. 58.—HALL DUPLEX PISTON PUMP.

of one division acts to operate the steam valve of the other, and *vice versâ*. In the cut the steam valve (a plain flat side) stands at the left of its stroke, admitting steam to the right of the main piston, mov-

ing it to the left. When the piston nearly reaches the end of its stroke and passes by the port *A*, port *B* meanwhile being closed (seen near the top of the cylinder), a sufficient portion of the pressure, which is moving the main piston, passes through this port across to and shifts the valve of the other engine, which then makes its stroke, and in a like manner admits steam to reverse the valve of the former. By proper location of the ports corresponding to *A* and *B*, in each cylinder, each engine must in its turn make a full stroke before giving steam to reverse the valve of the other. The admission of steam, however, being timed so that each engine starts a little before the other stops, for the purpose of keeping up a continous and uniform delivery of water.

The location of the ports *A* and *B*, near the end of the stroke of the pistons, causes each in its turn to pause (while the other is making its stroke) for a length of time sufficient to allow the seating of the pump valves by gravity.

The steam pistons cushion upon exhaust steam entrapped in the ends of the

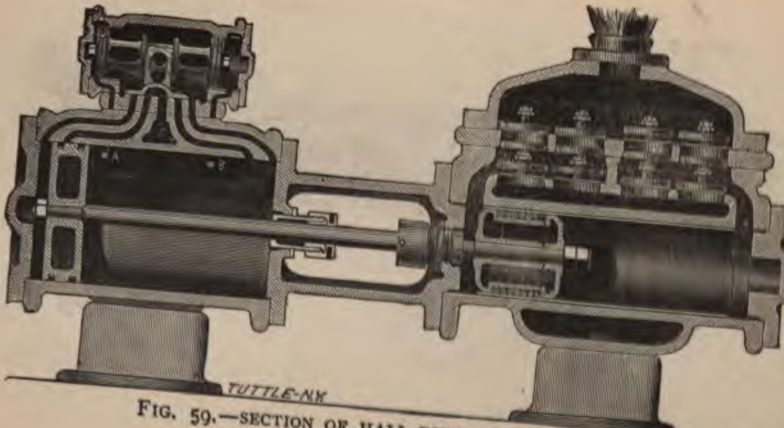


FIG. 59.—SECTION OF HALL DUPLEX PISTON PUMP.

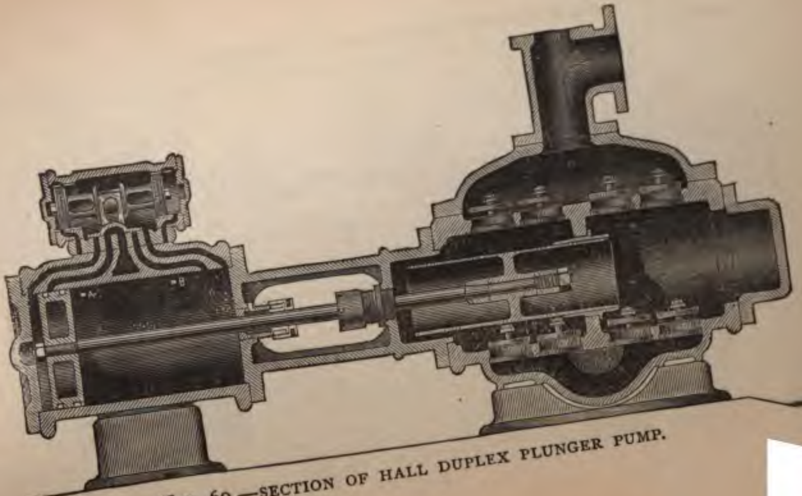


FIG. 60.—SECTION OF HALL DUPLEX PLUNGER PUMP.

cylinders, by reason of the pistons passing beyond the exhaust ports, the inlet ports at the ends of the cylinder being closed by the main steam valve.

The valves are plain flat disks of composition, or hard or soft rubber, working with a low lift upon a central stem.

Q. How would you proceed to put up a Hall pump, supposing it to be all apart?

A. Begin by providing proper packings for all steam and water joints. Next, bolt the bed plate or steam cylinder foot firmly to its place, then bolt the center pieces or cradles to the steam cylinders, taking care to have the small hole for drip pipes in one of the bars of the center pieces come at the bottom. Next, bolt the water cylinder foot firmly to its place. The steam and water cylinders should now be bolted together. Next proceed to screw in the studs for holding down steam chests, and then put on the intermediate valve plate or seat; the valve drivers or pistons may next be inserted into the chests and the heads bolted on. The slide valves may now be put in position in the chests, keeping the lug on the side of the valve toward the cavity on

one side of the chest. The chests and valves are now ready to be put in position and should be firmly bolted down. Next proceed by driving the water valve seats into their place in the water cylinder and intermediate valve plate, using the end of a block of wood having a flat surface. The valves and springs should then be put in place and the nuts or stems screwed down firmly. Now put on the intermediate valve plate and be sure to put in the center bolt and screw down solidly. The cap may then be put on and the air chamber bolted to its place. It now only remains to bolt on the suction and discharge flanges—if there be any—and put in the piston rods and steam and water pistons or plungers, taking great care to screw up the piston rod nuts solidly; the cylinder heads may then be bolted on and the drip cocks and plugs put in, and, after nicely packing the pump, it is all ready to be connected with the piping and put in operation.

(In taking apart and putting together the Hall pump, it is unnecessary to mark or separate the respective parts of the two sides of the machine, as they are exact

FIG. 61.—DETAILS OF HALL PUMP.

duplicates and w...
sary parts are provided with ...
or lugs to prevent their going on w...

Q. What is the construction and ... tion of the steam end of the Kr... direct acting steam pump?

A. There is an auxiliary piston ... works in the steam chest and driv... main valve. This auxiliary or " ... piston," as it is called, is driven bac... and forward by the pressure of ... carrying with it the main valve, ... valve, in turn, gives steam to the ... steam piston that operates the ... This main valve is a plain slide ... the B form, working on a flat seat...

The chest piston is slightly rot... the valve motion; this rotative m... places the small steam ports (w... located in the under side of t... piston) in proper contact with co...

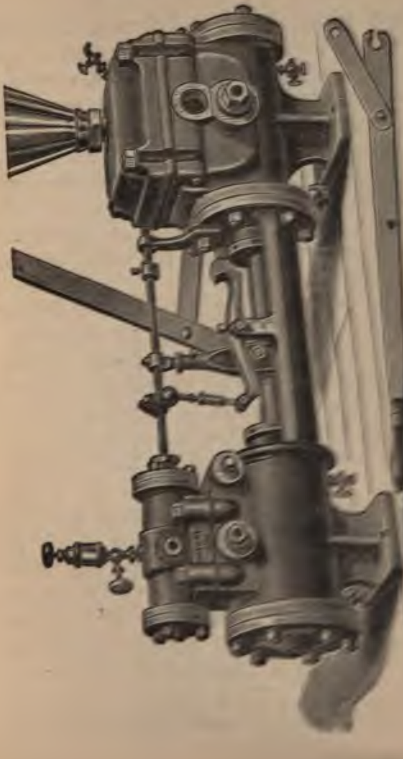


FIG. 66.—NEW PATTERN KNOWLES PUMP.

chest piston has traveled a certain distance, a port on the opposite end is uncovered and steam there enters, stopping its further travel by giving it the necessary cushion. In other words, when the rotative motion is given to the auxiliary or valve-driving piston by the mechanism outside, it opens the port to steam admission on one end, and at the same time opens the port on the other end to the exhaust.

The pump piston rod, with its tappet arm, moves backward and forward from the impulse given by the steam piston. At the lower part of this tappet arm is attached a stud or bolt on which there is a friction roller.* This roller, coming in contact with the "rocker bar," at the end of each stroke, operates the latter. The motion given the "rocker bar" is transmitted to the valve rod by means of the connection between, causing the valve rod to partially rotate. This action, as mentioned above, operates the chest piston, which carries with it the main slide valve. The said valve giving steam

* The friction roller, with its bolt and nut, can be lowered or raised, when it is desired, to adjust the pump for a longer or shorter stroke.

to the main piston, the operation of the pump is complete and continuous. The upper end of the tappet arm does not come in contact with the tappets on the valve rod, unless the steam pressure from any cause should fail to move the chest piston, in which case the tappet arm moves it mechanically. This feature makes the pump absolutely positive.

Q. How would you proceed to put a Knowles pump together and adjust it so that it would run right when started up; supposing that you had all the parts separated and lying on the floor?

A. The following covers the case completely.

1. Bolt the steam cylinder casting to the water cylinder casting. Place the piston rod stuffing boxes (No. 11) in place, first screwing the seats (No. 11 *A*) into the castings, then putting on the follower (No. 11 *B*) and the gland (No. 12).

2. Take the piston rod (No. 8) with its nut and lock nuts, and place it in the pump.

3. Take the tappet arm (No. 19) and bolt it on to the piston rod. This is to keep the rod from turning while the pis-

tons and the piston rod nuts are being placed in the pump.

NOTE.—Observe the little pinhole in the piston rod. A pin on the inner side of the tappet arm goes into this pinhole to keep the arm from turning on the rod. Screw up the two clamp bolts hard, so as to make a good job of it.

4. Now put the water piston (No. 10) in its cylinder. First place the piston head or body with the segments and brass ring. Then place the rings of canvas packing over the brass ring, being careful that the joint of one ring is not opposite the joint of another. In other words, "break joints."

5. Place the follower on and fasten it up tight with the follower bolts.

NOTE.—In the small pistons there are no follower bolts, as the piston rod nuts serve for that purpose.

6. Now take the socket wrench that accompanies every pump, and screw up hard the piston rod nut and lock nut (No. 9); then move the piston to and fro in the cylinder, and see if it is perfectly free. It does not do to have this piston fit too tight, because when water is in the cylinder, the packing will swell a little.

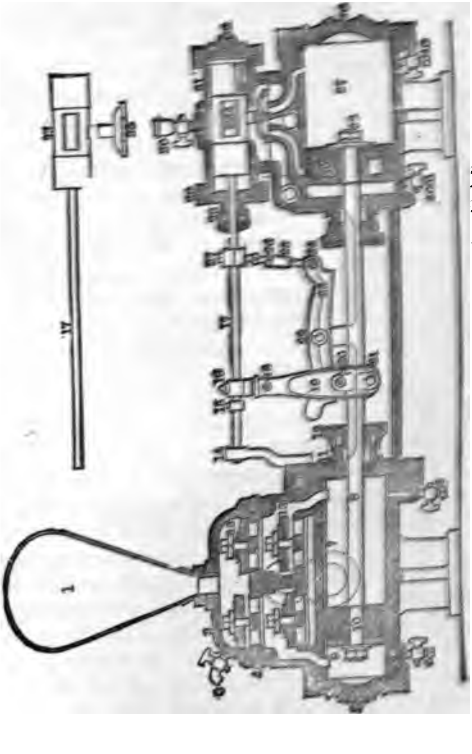


FIG. 63.—SECTION OF KNOWLES PUMP.

7. Push the rod as far as possible towards the steam end, and put in the steam piston (No. 39). First place the piston head or body (39 *A*) on the rod; then the packing rings (39 *B*). In the large size pistons there are studs and springs which need to be set out. Place on the follower (39 *C*), and then bring it up tight to the piston head by screwing up the nut and lock nut of the piston rod. Be careful to notice the dowel pin on inner face of follower and see that it fits into the hole in piston head.

NOTE.—On the large size pistons there are follower bolts, which fasten the follower to the piston head.

8. Now place on the steam cylinder head (36), and screw up the bolts tight (36 *A*). Do the same with the head of the water cylinder (No. 5).

9. We will now complete the fitting up of the water cylinder. The composition seats for the suction valves will be found fastened into the water cylinder casting, and also in the plate (No. 4) for the discharge valves. In case, however, you have to put in new valve seats (13 *C*), drive them in with a smooth piece of wood

placed over the face of the seat. Drive true and hard. Do not place any red lead, oil or other material on the valve seats before driving in. See that the surfaces are clean and dry, both of the seat and the hole in the casting.

NOTE.—The valve stems on which the valves move, are usually part of the composition castings that form the valve seats.

10. Now take the valves (13), slip them over the valve stems (13 *D*), seeing that the face of the valve is true and fair. Place on the coil springs (13 *E*) and screw the nuts and lock nuts on the end of valve stems.

NOTE.—Use soft rubber valves for cold water or other clear, cold liquids, and hard rubber valves for hot water or other heated clear liquids. There are also valves of special form for pumping special kinds of material; for instance, clapper valves for beer mash, etc.

11. Place the valve plate (4) on the pump, not omitting to screw the bolt (4 *A*) into its place in the middle of the plate. Now place on the water cap (2) with its air chamber (1). These are fastened down by swing bolts, which are on all our regu-

lar size pumps. To complete the fitting up of the water cylinder, do not forget to screw in the air cock (No. 3).

12. Now proceed to complete the steam end of the pump. Take the steam chest (31) and fit it up complete, first by putting in the chest piston (33). This is held in place by its guide pin (34). Before putting in this chest piston, fit into it the valve rod (17). The next thing to do is to put on the front steam chest head (32).

NOTE.—The joint between the chest and its head is a ground joint. If time cannot be taken to regrind it, make a clean paper joint of manilla wrapping paper. The bolts (32 *A*) screw up hard. Now place on the back steam chest head (29) in the same manner as the other head. This head contains the seat of the valve rod stuffing-box (28). Slip over the valve rod the follower and gland (28 *A*) of said stuffing-box, screwing them on to the seat ready for the packing.

13. Before placing the steam chest on the steam cylinder casting, move the chest piston, so that it is exactly in the middle of its cylinder. Then place the main slide valve (35) over its ports, exactly in

the middle. Drop the chest down, and you will find the upper projecting part of the main slide valve will slip into the slot designed for it in the chest piston.

NOTE.—Before fastening the steam chest down with its holding-down bolts (31 *B*), see to it that the rubber gasket that forms the joint between this chest and the steam cylinder is in good condition. Especially notice whether the small holes are cut in the gasket for the exhaust ports of the steam chest. A neglect to cut out these holes has often caused annoyance, for which the pump was often wrongly blamed.

14. To complete the pump, all that is now necessary is to fit up the valve gear. Proceed with this carefully, as follows: On the top of the tappet arm (19) is the tappet arm tip (16). Slip this tip over the valve rod (17), at the same time working it into its socket in top of the tappet arm; the set screw (No. 18) will secure the tappet arm tip firmly in place. Now slip over the valve rod, the collar and its set screw and gib (No. 15), fastening them in their proper position.

NOTE.—You will find a flat notch filed

in the valve rod for the reception of the gib or key of said collar. Slip the valve rod guide (14) over the end of the valve rod, and fasten it in its proper place on the water cylinder head by the bolt (14 *A*).

15. At the other end of the valve rod, near the steam chest, is a similar notch for the reception of the valve rod clamp (27). Fasten this clamp in position by its gib and bolts (27 *B* and 27 *A*).

NOTE.—Before placing on this clamp, fit the ball of the "*ball joint connection*" (26 *A*) into its socket, which is part of the casting forming said clamp. Fit on the rest of the rocker connection (25).

16. Now place in position the rocker bar (23), first fitting it up with its bolt, nut and washer. Be sure and not leave off this washer, and see that it is in its proper position *between* the rocker and the casting. Push the bolt into its hole, in the casting (that forms the center between the water and steam cylinders), and then screw up the nut on the bolt (22) firmly, after which screw down the set screw (22 *A*).

17. Complete the fitting up of the valve gear by attaching to the rocker bar the

rocker connection (25) by its bolt and nut (24). Join the rocker connection (25) with the ball joint connection (26 *A*), first placing on the rocker connection its lock nut (26). This nut is for locking after lengthening or shortening the connection, as will be further explained.

18. We will now adjust the valve motion. Please notice at the bottom part of the tappet arm, just above the piston rod, is the rocker roller (20) and its stud and nut (20 *A*). The adjustment of this is for lengthening or shortening the stroke of the pump. The rocker connection (25) and its parts are for adjusting the uniformity of the stroke, so that it moves the same distance each way. Before adjusting this rocker motion, take the rocker roller and move it up as high as possible. The pump will now make a very short stroke. Loosen the rocker connection set nut, and by a little pin, which should be placed through the hole in the rocker connection (26 *A*), lengthen or shorten the connection until you get a uniform stroke of the pump; that is to say, see that the tappet arm moves the same distance each way from the centre of the

pump. After you have secured a uniform motion each way, lock up the rocker connection tight by screwing hard on the lock nut (26) referred to. Now go back to the rocker roller (20), and gradually lower it until you get the proper length of stroke of pump. This roller coming in contact with the rocker bar (earlier or later in its stroke), regulates the length of stroke of the pump; consequently, as the rocker roller is raised or lowered, so will the length of the stroke be shorter or longer. After having secured a proper length of stroke by the adjustment of the rocker roller referred to, lock it up tight by screwing up hard the rocker roller nut (20 *A*).

NOTE.—The tappet arm tip (16) should never come in contact with the valve rod collar (15) or the clamp (27). Please note that the valve rod is not moved by the tappet arm coming in contact with these parts. It is moved, as before explained, by the combination of the rocker bar and the connection between it and the clamp, which gives a rotary motion to the valve rod.

The completion of the fitting up of the

pump, such as screwing in drip cocks (No. 6) for the water cylinder and the steam cylinder cocks (No. 4), etc., is of course understood as necessary.

Q. What is Letestu's pump?

A. The piston is conical, with the small end towards the suction side, and the en-

FIG. 64.—LETESTU'S PUMP ENGINE.

tire surface of this conical piston is covered with valves.

Q. What is the advantage of the Letestu pump?

A. Slight friction.

Q. What is the construction of the Pulsometer as now in the market?

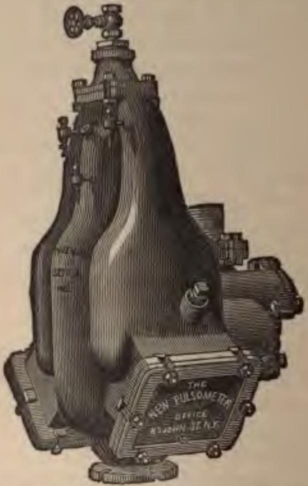


FIG. 65.—THE NEW PULSOMETER.

A. The Pulsometer consists principally of two bottle-shaped chambers, *A*, *A*, joined together side by side, with tapering

necks bent towards each other, to which is attached, by means of a flange joint, *B*, a continuous passage from each cylinder leading to one common upright passage into which a small ball, *C*, is fitted so as to oscillate with a slight rolling motion between seats formed in the junction.

These chambers also connect by means of openings with the vertical induction passage, *D*, which openings are so formed that the valves, *E*, *E*, consisting of vulcanized rubber, and their seats, *F*, *F*, constructed so as to sustain the valves, may be inserted.

The delivery passage, *H*, which is common to both chambers, is also constructed so that in the openings that communicate with each cylinder are placed valve-seats, *G*, *G*, fitted for the reception of the same style of valves as in the induction passage. *I*, *I*, are valve-guards to prevent the valves from opening too far.

To facilitate the removal of the valves and valve-seats, the flanges that cover the openings are slotted to receive the bolts, the nuts of which being loosened, they may be removed and the covers displaced.

J represents the vacuum chamber, cast

and between the necks of chambers
A, and connecting only with the induc-
passage below the valves *E*, *E*.
K, *K*, are flanges covering the openings

FIG. 66.—SECTION OF NEW PULSOMETER.

to the respective chambers, which may be
removed for the repair or renewal of valves
and seats, when necessary. Vent plug
are inseated into these flanges, for th

purpose of drawing off the water to prevent freezing.

L, L, are rods extending from the valve-guards to the set-screws *M, M*, by which the suction seats, valves and guards are tightly pressed to place.

N, N, are brass socket-headed bolts by which the discharge seats, valves and guards are drawn down to place.

A small brass air check-valve is screwed into the neck of each chamber, *A, A*, and one into the vacuum chamber *J*, so that their stems hang downward.

The check-valve in the neck of each chamber, *A, A*, allows a small quantity of air to enter above the water, to prevent the steam from agitating it on its first entrance, and thus form an air piston for preventing condensation.

The check-valve in the vacuum chamber, *J*, serves to cushion the ramming action of the water consequent upon the filling of the chambers alternately.

Q. What are the instructions as regards setting up the Pulsometer?

A. Connect the suction pipe to bottom of foot valve and drop to place. A strainer should be placed on the end of

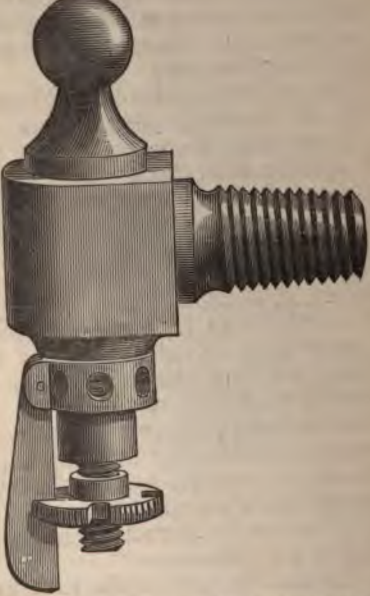


FIG. 67.—AIR VALVE OF PULSOMETER.

suction pipe to prevent substances from passing into the pump too large to pass the valves. Be sure the strainer is large enough to admit sufficient water to supply the pump. The Pulsometer raises much more water than other pumps with same size suction pipe, consequently if an ordinary strainer is used it should be a size or two larger, and bushed to fit the pipe.

To obtain best results from the Pulsometer, the vertical length of suction pipe should be no longer than will allow the pump to fill freely. The pump stands vertical, and the height of pump should be added to the suction.

No. 1 is 12 inches from bottom. Be careful to place the pump and valve in such a position that the covers can be removed most handily in case of any obstructions, or for renewing or turning over of the valves.

Connect the discharge pipe on from the discharge chamber. Connect the steam pipe to neck of pump with a globe valve near to operate with, and a union between valve and neck for the purpose of removing the neck to get at steam ball if necessary. Care should be taken in leading the joints

of steam pipe that none is allowed t
inside (unless the pipe is blown o
fore starting the pump) as it may p
the steam ball from seating.

Screw the air valves in tight, sc
their stems hang downward, as sh
cut, lift up the latch and screw the r
each up tight so as to close all the
and the pump is ready to operate.

Q. In case the Pulsometer is re
to work with excessive life, what p
tion should be taken?

A. In cases where it is absolutely
sary to place the pump high, an addi
foot valve should be placed on the e
pipe, and as little air admitted to the
through the air valves as will caus
pump to work without a rattle.

When the foot valve with suction
on is in place, lower the pump do
to templet of valve with gasket bet
and bolt tightly together.

Q. What are the instructions as r
starting the Pulsometer?

A. Steam being turned on at the
open the globe valve at the pum
sufficient to fill whichever chamb
steam ball will admit, and close it im

ately; repeat this until the pump is charged and the ball in neck rattles and kicks; leave the steam turned on, lift up latch and lower the nut on each air valve just sufficient to prevent the rattling and kicking of steam ball and causing a steady working of the pump, at which place allow the latch to fall in the nearest slot, which will firmly hold it to place. The steam may want to be shut off a little, as too much steam retards the working of the pump.

After once being charged, no trouble should be had in starting, if the globe valve is opened sufficiently, unless the rubber in foot valve gets stuck on some substance which prevents its closing and the charge is lost, in which case the cover should be removed, the valve cleaned, and started as above.

Q. Should you be unable to start the Pulsometer on first trial, and it becomes too hot to form vacuum, what shall be done?

A. Remove the plug in top of the air chamber, and fill with cold water, replace the plug, when it should start readily.

Q. Should the Pulsometer not fill or

start then, what is probably the matter i

A. There is some dirt around th steam ball, the suction connections ar not tight, or the rubber in foot valve doe not seat, all of which should be looked to

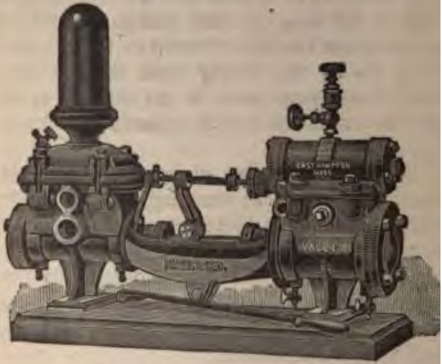


FIG. 68.—THE VALLEY PUMP.

Q. Describe the construction of th Valley steam pump?

A. The main valve is a plain slide valv of the B pattern, cast with a groov through its face (see fig. 69), and is move by an independent piston working in

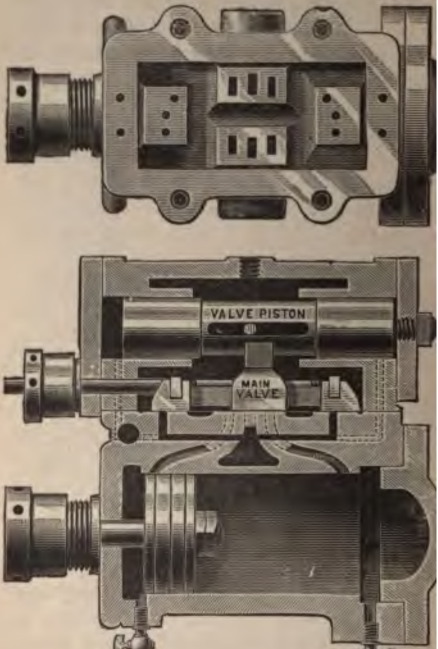
small cylinder above the main cylinder. The auxiliary valve (see fig. 69), which controls the steam to the valve piston, is made with two flat faces far enough apart to allow the main valve to work between them. These faces are connected together by a web which fits into the groove in the face of the main valve, so that both valves are out in sight when the steam chest is removed, and both work on the

FIG. 69.—VALVES OF VALLEY PUMP.

same plane. The auxiliary valve is moved by a tappet arm on the main piston rod, to prevent the pump having a dead centre.

Q. How would you proceed to examine and take apart a Valley steam pump?

A. To examine water valves, loosen nuts on top water cap, swing bolts down out of grooves, lift off water cap and valve plate.


VALVE PISTON
MAIN
VALVE

To examine water piston, remove water cylinder head and push both steam and water piston towards water end as far as they will go.

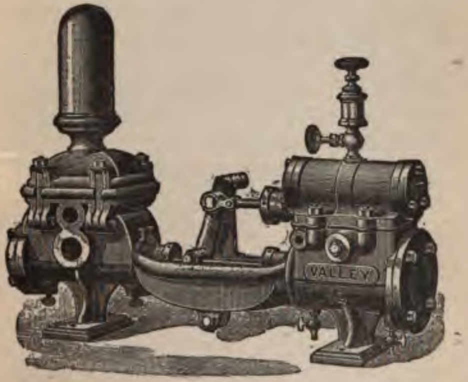


FIG. 71.—VALLEY PUMP.

To examine steam valves, remove steam chest, when both main and auxiliary valves will drop out.

To replace steam valves, turn face of steam chest upwards, put main valve in position by inserting lug on the back into

slot on the valve piston; then place aux iliary valve in position with lugs on valv stem in slots on back of auxiliary valve lay a piece of thin iron or the tongue of try-square over face of main valve; tur steam chest over carefully, holding valve in place, and place chest in position o pump. Insert two of the chest bolts an withdraw the piece of metal used to pre vent the valves from dropping out whe chest was turned over.

Q. What are the special features of th Lawrence (Webber) centrifugal pump?

A. (1). The branching of the suctio pipe, so that the fluid, being pumped, en ters the disk chamber from each side a and directly opposite the center of th revolving disk, forming a balanced suctio and dispensing with much of the frictio found in side suction centrifugal pumps (2). The pump case is bolted by flange to the "hood" of base by fou bolts in an annular T-headed slot, so tha the pump can be rotated on its own axi without detaching it from its base or dis turbing any of the rotary parts of th pump, thereby allowing the discharge t be taken off in any direction. (3). A

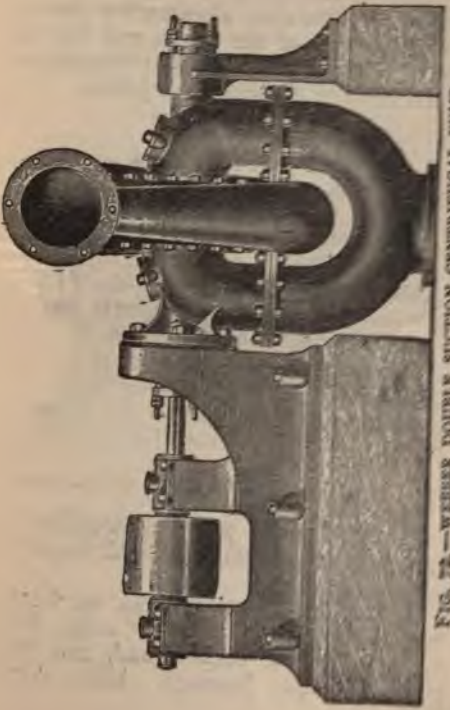


FIG. 72.—WEBER DOUBLE SUCTION CENTRIFUGAL PUMP.

removable cover, slightly larger than the diameter of the disc, allowing free access to the interior of the pump, and the removal of the disc without disturbing either the suction or discharge pipe joints.

FIG. 74.—DIRECT DRIVEN CENTRIFUGAL PUMP.

Q. How would you put together a Lawrence centrifugal pump, if all the parts were separate ?

A. Put the pump case on the base, insert bolts and "set them up" solid. Put the stuffing box inside gland, and the pulley between bearings. Drive shaft

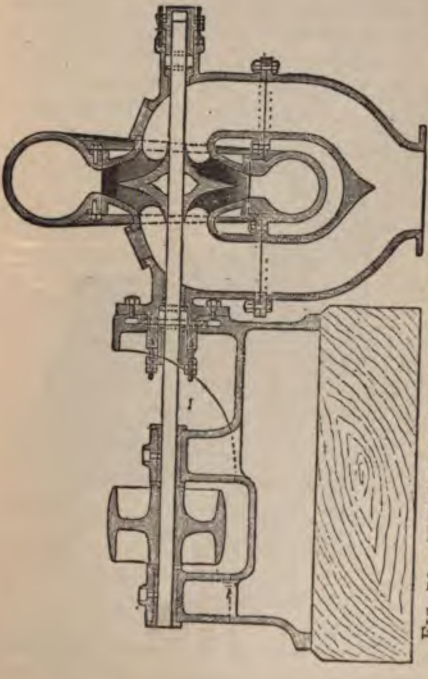


FIG. 73.—SECTION OF WEBBER CENTRIFUGAL DOUBLE SUCTION.

through until "disc" strikes face of pump. Put white lead on fitting ring, and bolt cover to pump. Then drive the shaft back until "disc" will turn without striking sides of pump. Pack stuffing boxes and test pump at 70 lbs. cold water pressure.

FIG. 75.—PORTABLE CENTRIFUGAL PUMP, WITH BOILER.

Q. What is the construction and operation of the Worthington pump?

A. Figure 77 is a sectional view of one side or half of a Worthington high pressure steam pump, of ordinary con-

struction. The steam valve, as may be seen at *E*, is an ordinary slide valve, working upon a flat face over ports or openings.

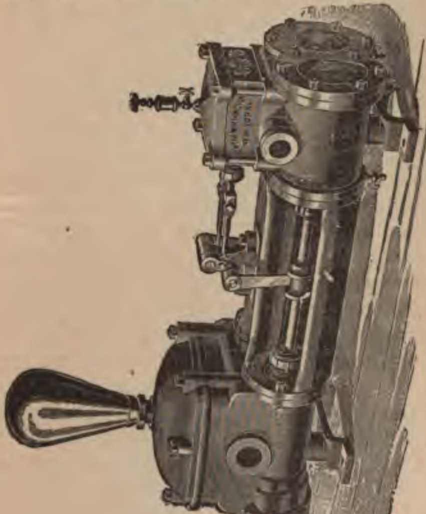


FIG. 76.—WORTHINGTON DUPLEX PUMP.

The motion of this valve is produced by a vibrating arm, seen at *F*, which swings through the whole length of the stroke.

The moving parts are always in contact. The double acting plunger, shown at *B*, works through a deep metallic packing ring, bored to an accurate fit, being neither elastic nor adjustable. If it be desired at any time to change the proportions between the steam pistons and pumps, a plunger of somewhat larger size, or decreased to any smaller diameter, can be substituted. The plunger is located some inches above the suction valves, to form a subsiding chamber, into which any foreign substance may fall below the wearing surfaces. The water enters the pump from the suction chamber *C*, through the suction valves, then passes partly around and partly by the end of the plunger through the force valves, nearly in a straight course, into the delivery chamber *D*. The valves consist of several small discs of rubber, or other suitable material, easy to examine and inexpensive to replace. Two steam cylinders and two pumps are placed together to form one machine. The right hand division moves the steam valve of the left hand one, and *vice versâ*. One pump takes up the motion when the other is about to lay it down.

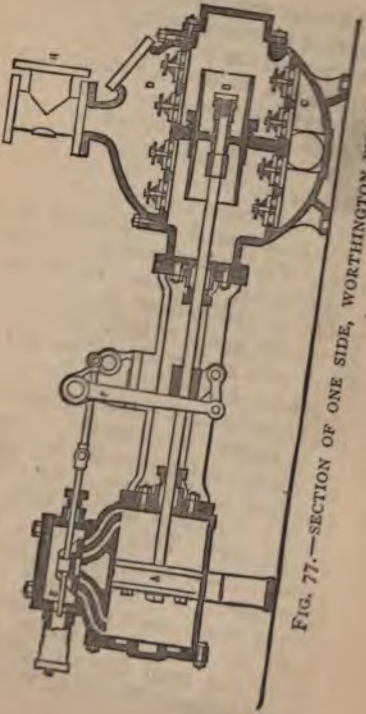


FIG. 77.—SECTION OF ONE SIDE, WORTHINGTON PUMP.

The valve motion is the prominent and important peculiarity of this pump. Two steam pumps are placed side by side, and so combined as to act reciprocally upon the steam valves of each other. The one piston acts to give steam to the other, after which it finishes its own stroke, and waits for its valve to be acted upon before it can renew its motion.

Q. How would you proceed to set the valves of a Worthington duplex pump?

A. To set the steam valves, move the piston to the end of its stroke until it comes in contact with cylinder head. Mark with scriber on piston rod at face of stuffing-box follower; then move piston to its contact stroke on opposite end; make another mark on the piston rod exactly half-way between the face of follower and first mark; then move piston back until the middle mark is at the face of stuffing-box. This operation brings the piston exactly at the middle of its stroke; then place the slide valve over steam ports; place valve nut between jaws on back of slide valve screw, valve rod; throw nut until eye on valve rod head comes in line with eye of valve link; slip

pin through head and valve is set. Repeat the operation with other side of

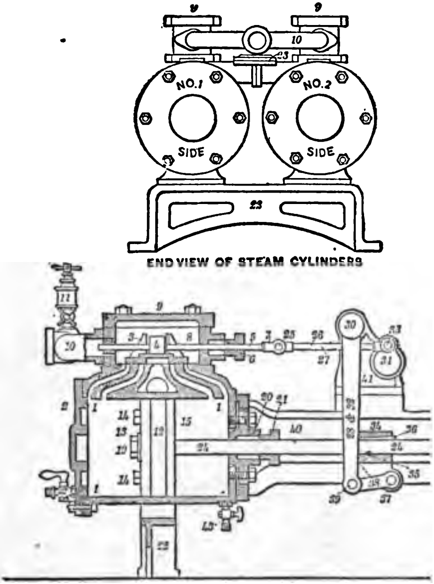


FIG. 78.—WORTHINGTON STEAM END, SHOWING DETAILS.

pump, and the valves will be properly set. The valves have no lap.

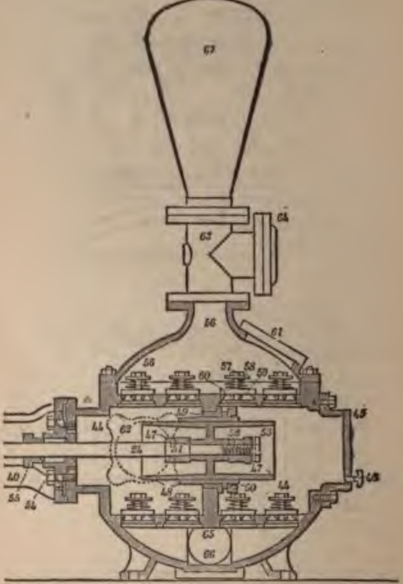


FIG. 79.—WORTHINGTON WATER END, SHOWING DETAILS.

NUMBERED LIST OF PARTS OF WORTHINGTON PUMP.

[In ordering parts state their name and number as below, also the size and the shop number of the pump.]

1. Steam Cylinder (No. 1 and No. 2).
2. Steam Cylinder Head.
3. Slide Valve.
4. Valve Rod Nut.
5. Valve Rod.
6. Valve Rod Gland.
7. Valve Rod Head.
8. Steam Chest.
9. Steam Chest Cover.
10. Steam Pipe.
11. Lubricator.
12. Piston Ring.
13. Piston Follower.
14. Piston Follower Bolts.
15. Piston Body.
16. Piston Spring.
17. Piston Tongue.
18. Piston Tongue Spring.
19. Piston Nut.
20. Piston Rod Stuffing Box.
21. Piston Rod Stuffing Box Gland.
22. Steam Cylinder Foot.
23. Exhaust Flange.

24. Piston Rod.
25. Valve Rod Head Pin.
26. Long Valve Rod Link.
27. Short Valve Rod Link.
28. Long Lever.
29. Rock Shaft Taper Pin.
30. Upper Rock Shaft.

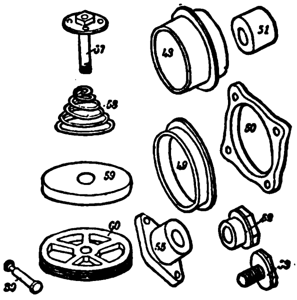


FIG. 80.—DETAILS OF WORTHINGTON PUMP.

31. Lower Rock Shaft.
32. Short Lever.
33. Crank Pin.
34. Crosshead.
35. Crosshead Position Pin.
36. Crosshead Key.

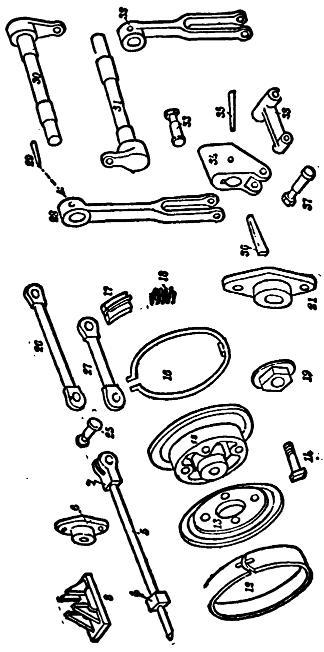


FIG. 81.—DETAILS OF WORTHINGTON PUMP.

37. Crosshead Pin.
38. Crosshead Link.
39. Lever Pin.
40. Cradle.
41. Cross-stand.
42. Waste Cock.
43. Pet Cock.
44. Water Cylinder.
45. Water Cylinder Head.
46. Thumb Plugs.
47. Plunger.
48. Plunger Ring.
49. Casing.
50. Binder.
51. Plunger Hub.
52. Plunger Nut.
53. Plunger Jam Plug.
54. Plunger Rod Stuffing Box.
55. Plunger Rod Stuffing Box Gland.
56. Force Chamber.
57. Valve Guard.
58. Valve Spring.
59. Valve.
60. Valve Seat.
61. Force Chamber Hand-hole Plate.
62. Water Cylinder Hand-hole Plate.
63. Delivery Tee.
64. Delivery Screw Flange.

65. Suction Screw Flange.
66. Suction Hand-hole Plate.
67. Air Chamber.

Q. Why is no mention made of some few makes of pumps?

A. The author made early application to every pump maker in the United States known to him, or whose address he could obtain from data concerning the construction, operation and adjustment of their pumps. In every case he distinctly stated that there was no charge, direct or indirect, for any publication of matter thus asked for, and in every case where data was forwarded (and in some where it was not, even after repeated applications), proper space and representation were accorded. He does not, therefore, consider himself responsible for the few omissions of mention which may be detected.

MISCELLANEOUS.

Q. What is meant by the efficiency of a pump?

A. The ratio between the work put into it and the work done by it.

Q. What is the efficiency of various pumps?

A. Claudel gives the following from actual tests:

	Efficiency. Per Cent.	Rates of Volume of Water to Piston Displacement. Per Cent.
Fire engines, height 10 to 16 feet.....	20.7	91
Fire engines, work with hose........	35.8	91
Pumps for drainage.	50 to 69	93
Pumps in town, single acting.........	70 to 75	90 to 95

Q. What is the efficiency of a good, ordinary reciprocating pump?

A. From 75 to 85 per cent.; very rarely more than 75 per cent.; often less.

Q. What is the proportion between the

volume of liquid raised and the volume passed through the piston?

A. In good pumps about 96 to 97 per cent.; in ordinary pumps, only about 80 to 90 per cent.

Q. What has an influence upon the proportion between the volume of liquid and the piston displacement?

A. The speed of piston.

Q. May the volume of water exceed that of the piston displacement?

A. Yes, if the piston speed is very great.

Q. How high will an ordinarily good pump draught water?

A. About 27 feet at the sea level.

Q. What is the meaning of the word "duty," and what is its origin?

A. About 1778, Bolton and Watt introduced the term to express the performance of their engines in Cornwall, in cases where they were paid out of the profits resulting from the saving of fuel.

Q. What is Bailey's method of calculating the duty of pumping engines?

A. Multiply the area of the plunger in square inches by the pressure per square inch in pounds; this to give the load in

pounds; this times the feet per hour moved by the plunger, and times the constant 100 divided by the coal per hour in pounds, gives the duty. Thus: Suppose the plunger to have an area of 373.55 square inches, and the water pressure to be 75.68 pounds per square inch, then the load will be 28.293 pounds. If the plunger speed is 10,908.4 feet per hour, and the coal consumption 400 pounds per hour, then the duty will be $28.293 \times 10{,}908.4 \times 100 \div 400 = 77{,}157{,}840$, representing the number of pounds of water lifted one foot high by 100 pounds of coal.

The same thing may be figured out thus: Multiply the displacement per stroke in cubic feet by the number of strokes per hour, by the weight of water per cubic foot in pounds, by the height in feet, and by the constant one hundred, and divide by the coal per hour in pounds.

Thus: 10.4042 (cu. ft.) × 2722 (strokes) × 62.5* (pounds) × 174.82 (feet) × 100 ÷ 400 (pounds of coal per hour) = 77,358-478.

* This is too great. See under the head of "weight of water."

Q. What is Graft's formula for the duty of pumping engines?

A. $P \times V \times H \times 100 \div F =$ duty, where P represents pounds of water delivered per stroke, as ascertained by measurement of the plungers and calculations of their displacement; V, the number of strokes made during the trial; H, the head pressure in feet, including friction through main, as ascertained by gauges placed on the ascending main, just beyond the air chamber; F, the number of pounds of coal actually consumed during the trial, not deducting ashes or clinkers, nor reckoning the coal used in getting up steam, nor banking fires.

Q. Should the duty of pumping engines be rated in pounds of water one foot high per pound of coal, or per pound of steam; and why?

A. Duty should be expressed in pounds of water one foot high per pound of steam at a standard or stated pressure and degree of dryness, because the latter is a regular method, representing a substance having fixed value, while the other is expressed in very variable units. Some boilers will evaporate much more water per pound of coal than others.

Q. About what is the duty of small lift pumps?

A. When lifting 15 feet they have been found to have a duty of 15 to 40 per cent. Through long lines of hose they have been found to have a duty of 57 per cent. as a maximum.

Q. Why should the resistance that a pump has to work against be represented by pounds per square inch instead of by feet of water?

A. Because in many cases, as, for instance, boiler feed pumps, there is no height of water; there is only pressure in pounds per square inch or other convenient unit.

Q. How far will a centrifugal pump force water?

A. It will not force at all. You can put a valve on the discharge pipe of the pump and shut it tight, and the pump will continue to run just the same, and a gauge on the pipe show no pressure at all, no matter what the speed of pump.

Q. What are the advantages of centrifugal pumps?

A. They have no complication of parts; will discharge a greater quantity of water in proportion to the power expended than

any others; will discharge a steady stream without any air chambers; are but little affected by grit or other substances in the liquid pumped; will pass large bodies through them; will pump hot liquids well; require little or no foundation.

Q. What is one disadvantage of centrifugal pumps?

A. "There is a continual lessening of the quantity of water per revolution pumped as the number of revolutions per minute increases" (Isherwood).

Q. Where are plunger pumps desirable?

A. Where the water is gritty or the pressure is very great.

Q. What special precautions about hot liquids?

A. They should not be as high a lift as for cold; in some cases they may have to be let flow to the pump by gravity.

Q. Why cannot hot water be pumped as well as cold?

A. Because when the pump sucks there is a partial vacuum formed, and the hot water gives off vapor under the low pressure; this vapor filling the pump barrel and suction pipe, to the exclusion of the hot water.

Q. Is there much difference between the amount of hot water that can be pumped and that of cold, by a pump of a given capacity?

A. There is considerable difference under some circumstances. The rules which govern this case are the subject of very complicated formulas, interspersed with "constants." I have, however, the record of some tests made by H. J. Coles, with a pump 3″ x 7″, and we get from him the first three columns of the following table:

RESULT OF EXERIMENTS WITH A PUMP 15 FEET ABOVE THE WATER LEVEL.

Revolutions Per Minute.	Temperature, F.	Hot Water Pumped Per Minute.	Hot Water Pumped Per Stroke.	Weight of One Cubic Inch.	Weight of Water Pumped Per Stroke.
		Cu. In.	*Cu. In.*	*Lbs.*	
70	70	3430	490	.03606	17.669
70	100	3430	490	.03588	17.581
70	120	3430	490	.03569	17.488
70	140	3430	490	.03552	17.405
70	160	3286	469½	.03529	16.569
60	170	2682	447	.03511	15.694
50	180	2180	436	.03503	15.273

Each quantity stated is the mean of several trials. Above 180° F. scarcely any water could be pumped. According to Regnault, 185° would be the limiting temperature at 15 feet.

I have added to Mr. Coles' figures some other columns. The fourth shows the quantity of water pumped per revolutions; the fifth, the weight of one cubic inch of water at the various temperatures there given, and the sixth, the weight of water pumped per stroke.

Q. Is it easier to pump into a tank if the pipe is carried over the top or to pump into the bottom? and why?

A. The latter is the easier, because there is slightly less head of water to pump against.

Q. Does a tank 6 feet in diameter exert more pressure upon a pump than a 3-inch pipe having the same height and head?

A. No. The pressure is according to the height of the column and not according to the cross section of its top.

CALCULATIONS.

Q. How do you get the circumference

of a circle when the diameter or the radius is given?

A. Multiply the diameter by 3.1416, or more nearly by 3.1415926; or multiply the radius by 6.2832, or more nearly by 6.2831852.

Q. How do you find the area of a circle?

A. Multiply the square of the diameter by .7854; or multiply the square of the radius by 3.1416.

Q. How do you find the diameter of a circle having a given area?

A. Divide the area by .7854 and take the square root of the quotient.

Q. How do you find the radius of a circle having a given area?

A. Divide the area by 3.1416 and take the square root of the product.

Q. How do you find the diameter of a circle having twice the area of a circle having a given diameter?

A. Find the area of the given circle; double it, and then find the diameter by the rule next but one before this. Or, shorter still, take the square root of twice the square of the diameter of the given circle. Thus a circle to have twice the area of one 6 inches in diameter should

have a diameter equal to the square root of twice the square of 6; that is, the square root of 72, which is 8.4853.

Q. How do you square a number?

A. Multiply it by itself; thus: $6 \times 6 = 36$.

Q. How do you find the cube of a number?

A. Use it three times as a factor. Thus: $6 \times 6 \times 6 = 216$.

Q. How do you get the square root of a number?

A. This explanation would take up too much time. The rules and several examples showing how to point off, etc., are given in the author's "Square Root Made Easy."*

Q. How do you find the diameter of a circle having half the area of a pipe of a given diameter?

A. Square the given diameter; halve this square; take the square root of the half square. Thus, a pipe to have half the area of one of 6 inches in diameter should have a diameter equal to the square root of one-half 36; that is, equal to $\sqrt{18}$, or 4.2426.

*Practical Publishing Co., 5 Dey St., N. Y. Price 50 cents, post-paid to any address.

Q. How do you measure the effective work done by a pump?

A. Multiply the weight of the liquid raised by the height to which it is raised, counting between levels.

Q. Given the diameter of water cylinder, the water pressure to be pumped against and the steam pressure, how do you determine the diameter of the steam cylinder?

A. Divide the water pressure by the steam pressure, square the diameter of the water cylinder, multiply by this ratio and take the square root of the product. (This supposes that the length of stroke is the same in both cylinders.) If the water pressure required be less than the steam pressure, the ratio will be less than 1; but the rule is the same.

Thus: Steam pressure, 60 pounds; desired water pressure, 300 pounds; water cylinder, 6 inches in diameter—then

$$\sqrt{\frac{6 \times 6 \times 300}{60}} = \sqrt{180} = 13.4+\text{inches.}$$

Steam pressure, 150 pounds; water pressure desired, 75 pounds; diameter of water

cylinder, 5 inches; then diameter of steam cylinder=

$$\sqrt{\frac{5 \times 5 \times 75}{150}} = \sqrt{12.5} = 3.53 + \text{inches.}$$

This makes no allowance for friction of the pump parts and of the water in the passages. It is best to allow about 50 per cent. margin for this; so that in the first case the pump should have a diameter of $\sqrt{180 + 90} = \sqrt{270} = 16.431$, and in the second a diameter of $\sqrt{12.5 + 6.25} = \sqrt{18.75} = 4.33$.

Q. How do you find the pressure in pounds per square inch, of a column of water?

A. Multiply the height of the column in feet by 4.34. More roughly, allow 27 inches (or two and a quarter feet) to the pound.

Q. How do you find the quantity of water raised per minute at a piston speed of 100 feet per minute?

A. Square the diameter of the water cylinder in inches, and multiply by 4 (approximation). Thus: A 10-inch cylinder will raise $10 \times 10 \times 4 = 400$ gallons per minute.

Q. How do you find the diameter of pump cylinder required to move a given number of gallons of water per minute at a piston speed of 100 feet per minute?

A. Divide the number of gallons per minute by 4 and take the square root of the quotient. Thus: To raise 2000 gallons of water per minute at 100 feet per minute piston speed, would take a pump cylinder of $\sqrt{\frac{2000}{4}} = \sqrt{500} =$ about 22.4 inches diameter.

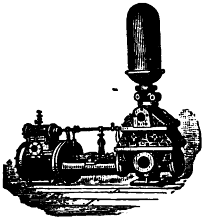
Q. How do you find the velocity of flow of water in a pipe, required to discharge a given volume of water in a given time?

A. Multiply the number of cubic feet of water by 144, and divide the product by the area of the pipe in inches. Thus to discharge 1000 cubic feet of water per minute through a 6-inch pipe, take a velocity of flow of $\frac{1000 \times 144}{6 \times 6 \times .7854} = \frac{144{,}000}{28.27}$ $= 509.3$ feet per minute.

Q. How do you find the diameter of pipe required to discharge a given volume of water at a given speed per minute?

A. Multiply the number of cubic feet of water per minute by 144; divide by the velocity of flow in feet per minute; divide by .7854; take the square root. Thus: To discharge 500 cubic feet of water per minute at a velocity of 1000 feet per minute, would require a pipe having a diameter of

$$\sqrt{\frac{500 \times 144}{1000 \times .7854}} = \sqrt{\frac{72{,}000}{785.4}} = 91.62 +.$$



USEFUL TABLES.

AREAS OF CIRCLES.

The following table will be found to save much trouble:

AREAS OF CIRCLES.

Diam.	Area.	Diam.	Area.	Diam.	Area.	Diam.	Area.	Diam.	Area.	Diam.	Area.
⅛	.012	½	23.75	16 in.	201.06	½	551.5	37 in.	1075.2	½	1772.0
¼	.049	6 in.	28.27	½	213.82	27 in.	572.5	½	1104.4	48 in.	1808.5
⅜	.110	½	33.18	17 in.	226.98	½	593.9	38 in.	1134.1	½	1847.4
½	.196	7 in.	38.48	½	240.52	28 in.	615.7	½	1164.1	49 in.	1885.7
¾	.441	½	44.17	18 in.	254.46	½	637.9	39 in.	1194.6	½	1924.4
1 in.	.785	8 in.	50.26	½	268.80	29 in.	660.5	½	1225.4	50 in.	1963.5
⅛	.994	½	56.74	19 in.	283.53	½	683.4	40 in.	1256.6	½	2002.9
¼	1.227	9 in.	63.61	½	298.64	30 in.	706.8	½	1288.2	51 in.	2042.8
½	1.767	½	70.88	20 in.	314.16	½	730.6	41 in.	1320.2	½	2083.0
¾	2.405	10 in.	78.54	½	330.06	31 in.	754.7	½	1352.6	52 in.	2123.7
2 in.	3.141	½	86.59	21 in.	346.36	½	779.3	42 in.	1385.4	½	2164.7
¼	3.976	11 in.	95.03	½	363.05	32 in.	804.2	½	1418.6	53 in.	2206.1
½	4.908	½	103.87	22 in.	380.13	½	829.5	43 in.	1452.2	½	2248.0
¾	5.939	12 in.	113.10	½	397.60	33 in.	855.3	½	1486.1	54 in.	2290.2
3 in.	7.06	½	122.71	23 in.	415.47	½	881.4	44 in.	1520.5	½	2332.8
¼	8.29	13 in.	132.73	½	433.73	34 in.	907.9	½	1555.2	55 in.	2375.8
½	9.62	½	143.13	24 in.	452.39	½	934.8	45 in.	1590.4	½	2419.2
¾	11.04	14 in.	153.94	½	471.43	35 in.	962.1	½	1625.9	56 in.	2463.0
4 in.	12.56	½	165.13	25 in.	490.8	½	989.8	46 in.	1661.9	½	2507.1
½	15.90	15 in.	176.71	½	510.7	36 in.	1017.8	½	1698.2	57 in.	2551.7
5 in.	19.63	½	188.69	26 in.	530.9	½	1046.3	47 in.	1734.9	½	2596.7

TABLE of Squares, Cubes, Square Roots, Cube Roots, Reciprocals and Natural Logarithms, from 1 to 100.

No.	Sq.	Cu.	Sq. Rt.	Cu. Rt.	Recip.	Log.
1	1	1	1.0000	1.0000	1.0000	0.0000
2	4	8	1.4142	1.2599	0.50000	0.3010
3	9	27	1.7321	1.4422	0.33333	0.4771
4	16	64	2.0000	1.5874	0.25000	0.6021
5	25	125	2.2361	1.7100	0.20000	0.6990
6	36	216	2.4495	1.8171	0.16667	0.7781
7	49	343	2.6458	1.9129	0.14286	0.8451
8	64	512	2.8284	2.0000	0.12500	0.9031
9	81	729	3.0000	2.0801	0.11111	0.9542
10	100	1000	3.1623	2.1544	0.10000	1.0000
11	121	1331	3.3166	2.2240	0.09091	1.0414
12	144	1728	3.4641	2.2894	0.08333	1.0792
13	169	2197	3.6056	2.3513	0.07692	1.1139
14	196	2744	3.7417	2.4101	0.07143	1.1461
15	225	3375	3.8730	2.4662	0.06667	1.1761
16	256	4096	4.0000	2.5198	0.06250	1.2041
17	289	4913	4.1231	2.5713	0.05882	1.2304
18	324	5832	4.2426	2.6207	0.05556	1.2553
19	361	6859	4.3589	2.6684	0.05263	1.2788
20	400	8000	4.4721	2.7144	0.05000	1.3010
21	441	9261	4.5826	2.7589	0.04762	1.3222
22	484	10648	4.6904	2.8020	0.04545	1.3424
23	529	12167	4.7958	2.8439	0.04348	1.3617
24	576	13824	4.8990	2.8845	0.04167	1.3802
25	625	15625	5.0000	2.9240	0.04000	1.3979
26	676	17576	5.0990	2.9625	0.03846	1.4150
27	729	19683	5.1962	3.0000	0.03704	1.4314
28	784	21952	5.2915	3.0366	0.03571	1.4472
29	841	24389	5.3852	3.0723	0.03448	1.4624
30	900	27000	5.4772	3.1072	0.03333	1.4771

No.	Sq.	Cu.	Sq. Rt	Cu. Rt.	Recip.	Log.
31	961	29791	5.5678	3.1414	0.03226	1.4914
32	1024	32768	5.6569	3.1748	0.03125	1.5052
33	1089	35937	5.7446	3.2075	0.03030	1.5185
34	1156	39304	5.8310	3.2396	0.02941	1.5315
35	1225	42875	5.9161	3.2711	0.02857	1.5441
36	1296	46656	6.0000	3.3019	0.02778	1.5563
37	1369	50653	6.0828	3.3322	0.02703	1.5682
38	1444	54872	6.1644	3.3620	0.02632	1.5798
39	1521	59319	6.2450	3.3912	0.02564	1.5911
40	1600	64000	6.3246	3.4200	0.02500	1.6021
41	1681	68921	6.4031	3.4482	0.02439	1.6128
42	1764	74088	6.4807	3.4760	0.02381	1.6232
43	1849	79507	6.5574	3.5034	0.02326	1.6335
44	1936	85184	6.6332	3.5303	0.02278	1.6435
45	2025	91125	6.7082	3.5569	0.02222	1.6532
46	2116	97336	6.7823	3.5830	0.02174	1.6628
47	2209	103823	6.8557	3.6088	0.02128	1.6721
48	2304	110592	6.9282	3.6342	0.02083	1.6812
49	2401	117649	7.0000	3.6593	0.02041	1.6902
50	2500	125000	7.0711	3.6840	0.02000	1.6990
51	2601	132651	7.1414	3.7084	0.01961	1.7076
52	2704	140608	7.2111	3.7325	0.01923	1.7160
53	2809	148877	7.2801	3.7563	0.01887	1.7243
54	2916	157464	7.3485	3.7798	0.01852	1.7324
55	3025	166375	7.4162	3.8030	0.01818	1.7404
56	3136	175616	7.4833	3.8259	0.01786	1.7482
57	3249	185193	7.5498	3.8485	0.01754	1.7559
58	3364	195112	7.6158	3.8709	0.01724	1.7634
59	3481	205379	7.6811	3.8930	0.01695	1.7709
60	3600	216000	7.7460	3.9149	0.01667	1.7782
61	3721	226981	7.8102	3.9365	0.01639	1.7853
62	3844	238328	7.8740	3.9579	0.01613	1.7924
63	3969	250047	7.9373	3.9791	0.01587	1.7993
64	*4096*	262144	8.0000	4.0000	0.01563	1.8062
65	*4225*	274625	8.0623	4.0207	0.01538	1.8129

No	Sq.	Cu.	Sq. Rt.	Cu. Rt.	Recip.	Log.
66	4356	287496	8.1240	4.0412	0.01515	1.8195
67	4489	300763	8.1854	4.0615	0.01493	1.8261
68	4624	314432	8.2462	4.0817	0.01471	1.8325
69	4761	328509	8.3066	4.1016	0.01449	1.8388
70	4900	343000	8.3666	4.1213	0.01429	1.8451
71	5041	357911	8.4261	4.1408	0.01408	1.8513
72	5184	373248	8.4853	4.1602	0.01389	1.8573
73	5329	389017	8.5440	4.1793	0.01370	1.8633
74	5476	405224	8.6023	4.1983	0.01351	1.8692
75	5625	421875	8.6603	4.2172	0.01333	1.8751
76	5776	438976	8.7178	4.2358	0.01316	1.8808
77	5929	456533	8.7750	4.2543	0.01299	1.8865
78	6084	474552	8.8318	4.2727	0.01282	1.8921
79	6241	493039	8.8882	4.2908	0.01266	1.8976
80	6400	512000	8.9443	4.3089	0.01250	1.9031
81	6561	531441	9.0000	4.3267	0.01235	1.9085
82	6724	551368	9.0554	4.3445	0.01220	1.9138
83	6889	571787	9.1104	4.3621	0.01205	1.9191
84	7056	592704	9.1652	4.3795	0.01190	1.9243
85	7225	614125	9.2195	4.3968	0.01176	1.9294
86	7396	636056	9.2736	4.4140	0.01163	1.9345
87	7569	658503	9,3274	4.4310	0.01149	1.9395
88	7744	681472	9.3808	4.4480	0.01136	1.9445
89	7921	704969	9.4340	4.4647	0.01124	1.9494
90	8100	729000	9.4868	4.4814	0.01111	1.9542
91	8281	753571	9.5394	4.4979	0.01099	1.9590
92	8464	778688	9.5917	4.5144	0.01087	1.9638
93	8649	804357	9.6437	4.5307	0.01075	1.9685
94	8836	830584	9.6954	4.5468	0.01064	1.9731
95	9025	857375	9.7468	4.5629	0.01053	1.9777
96	9216	884736	9.7980	4.5789	0.01042	1.9823
97	9409	912673	9.8489	4.5947	0.01031	1.9868
98	9604	941192	9.8995	4.6104	0.01020	1.9912
99	9801	970299	9.9499	4.6261	0.01010	1.9956
100	10000	1000000	10.0000	4.6416	0.01000	2.0000

FACTORS AND CONSTANTS.

To reduce Centigrade degrees to Fahrenheit, multiply by 9-5, and if above zero, add 32°.

To reduce Fahrenheit degrees to Centigrade, subtract 32° and multiply by 5-9.

62° Fahr. equals 16.67° Cent.; 68° Fahr. equals 20° Cent.; 100° Fahr. equals 37.78° Cent.; 150° Fahr. equals 65.56° Cent.

Dark red color indicates about 700° Cent. equals 1292° Fahr.; cherry red, 1652° Fahr.; white heat 2372° Fahr.

Air at constant pressure expands 1-461 of its volume for each degree Fahr. above zero.

A column of water 2.3093 feet (or 27.71 inches high,) at 62° Fahr. will exert a pressure of one pound per square inch.

A column of water 33 947 feet high, at 62° Fahr., will exert a pressure of one atmosphere equals 14.7 pounds per square inch.

1728 cubic inches, 2200.15 cylindrical inches, 3300.23 spherical inches, or 6600.45 conical inches make one cubic foot.

One inch equals 2.53995 centimeters.

One foot equals 0.3048 metre.

One square inch equals 6.45148 square centimeters.

One square foot equals 0.092901 square metre.

One square yard equals 0.836112 square metre.

One litre equals 61.02524 cubic inches, or 0.8804 quarts.

One metre equals 39.37043 inches equals 3.28087 feet equals 1.09362 yard.

One kilogrammeter equals 0.672 lb. per foot equals 2.016 lbs. per yard.

INDEX

TO THE

PUMP CATECHISM.

An asterisk (*) denotes one or more illustrations.

[In looking for any subject having more than one word, look first for what appears to you to be the principal word, and if you do not find it under the initial letter of that word, try under that of the other. The frequently recurring word "pump," however, hardly appears as a heading in this Index, for obvious reasons.]

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